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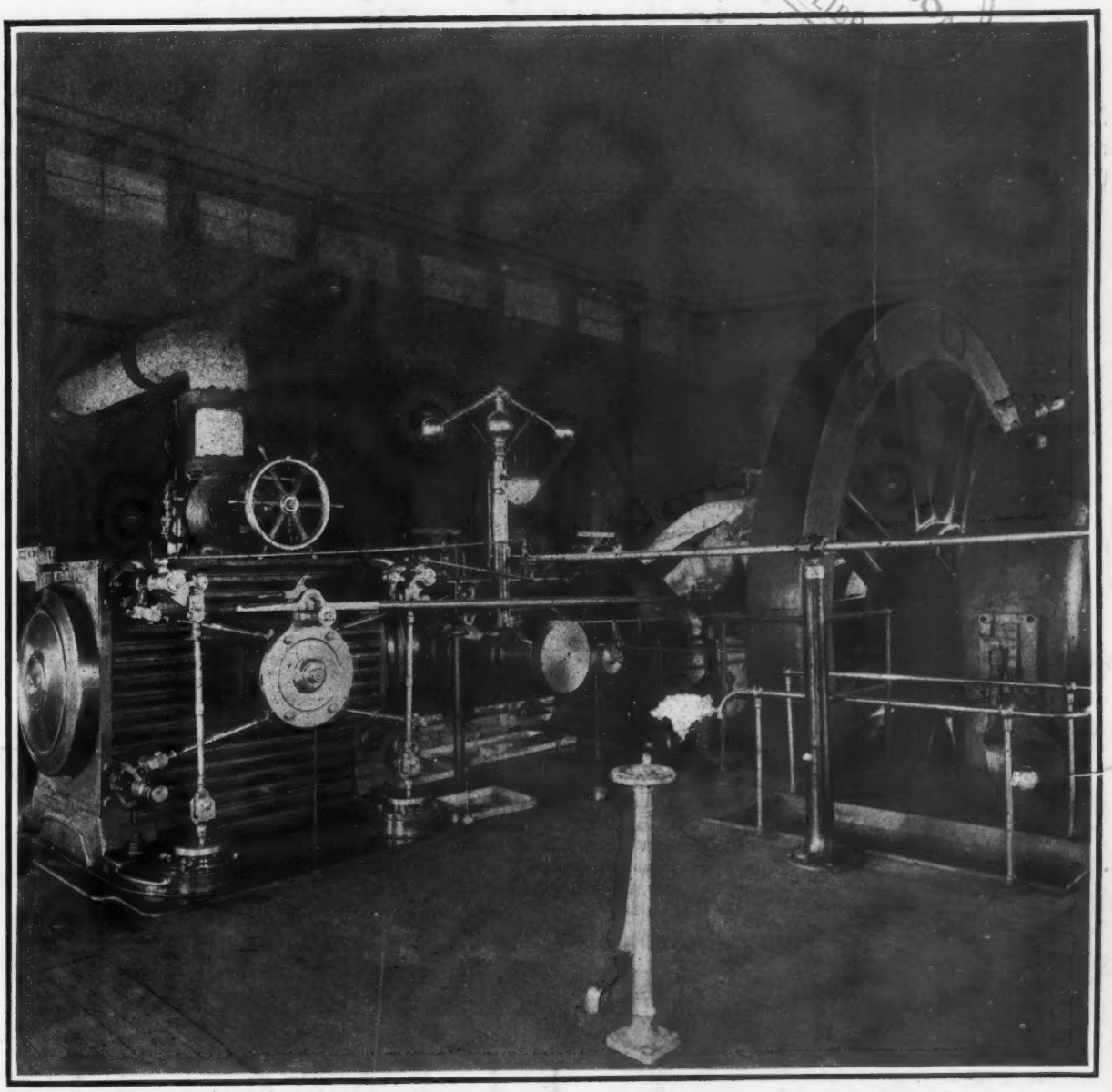

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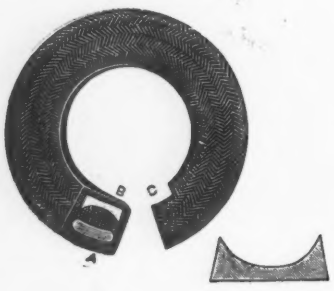

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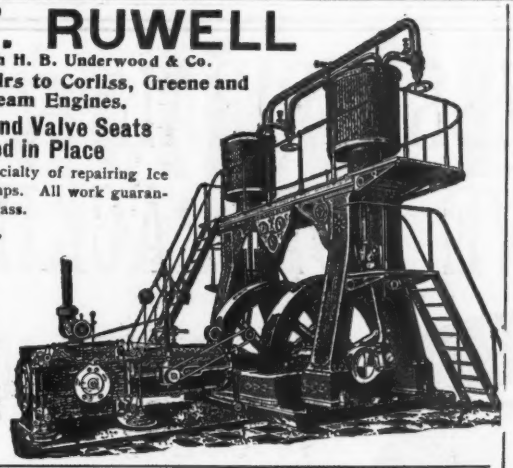

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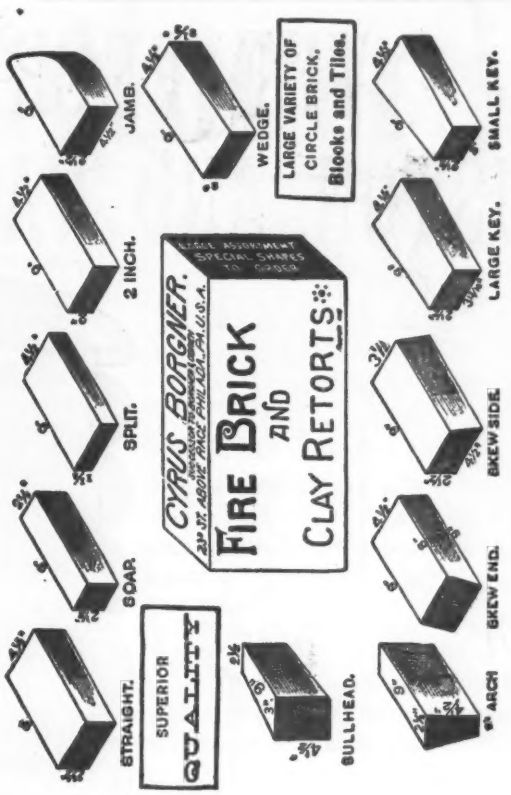

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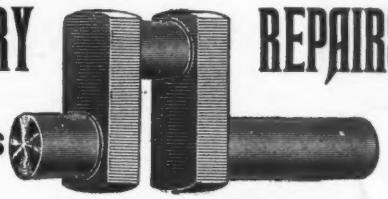

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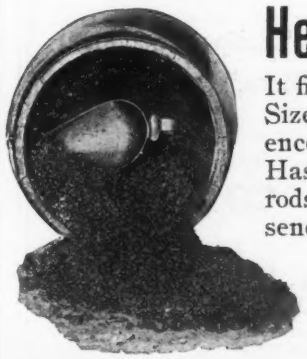

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The Kind of Coal to Select

BY R. T. STROHM.

The power developed by the dynamo, is, after all, derived from the latent heat energy of the boiler fuel, and the cost of this production will depend very largely upon the nature of the fuel used. At the present time coal is by far the most common boiler fuel, though the use of gas and oil and various types of refuse has grown to considerable proportions. However, coal still maintains the lead as a source of heat energy for power generation.

Coal may be divided into two leading classes, known as anthracite or hard coal and bituminous or soft coal, and we may class all of the various kinds of coal under one or the other of these general heads. No matter which class it belongs to, however, each grade of coal consists of two essential elements, carbon and hydrogen, and it is upon the relative proportion of these two elements that its heating value depends. There are other substances in coal which affect the heat per pound, such as moisture, sulphur and incombustible matter. But the combustible elements are the main factors in determining the heating value.

The first general class, or anthracite, consists mainly of pure carbon and contains a very small amount of volatile hydrocarbons, or volatile gases which may be driven off by the heat of the furnace. From a large number of test of anthracite samples it has been found that the fixed carbon varies from about 92 per cent. upwards, while the volatile hydrocarbons may represent 8 per cent. or less of the fuel. It is the predominance of the carbon element which makes anthracite so hard to burn.

Bituminous coal, on the other hand, is very rich in volatile hydrocarbons and comparatively poorer in fixed carbon. The percentage of volatile matter may vary from 25 per cent. upwards, and the fixed carbon forms about 75 per cent. of the fuel. Inasmuch as it contains so much gas-forming matter it is easy to ignite and easy to burn.

Between the bituminous and the anthracite classes may be placed two other divisions, known as semi-bituminous and semi-anthracite coal. The former contains a little more fixed carbon and a little less volatile matter than bituminous coal, and the latter contains a little more volatile matter and a little less fixed carbon than anthracite coal. With these four varieties to choose from, then, the question confronting the engineer or power user is, "Which shall I select in order to obtain the best economy?"

The answer is by no means easy. In general, however, that coal is most valuable which will evaporate the greatest amount of water at the least expense. But here comes the difficulty. The evaporative efficiency of a steam boiler takes into account not only the furnace efficiency but likewise the efficiency of the evaporator itself. In consequence, the decision as to the kind of coal to be used must be based upon and influenced by the type of furnace and the type of boiler and setting, or in general terms, by the conditions of operation. A coal which is unsuited to a certain construction of boiler or furnace will give poor results in a test, whereas, used under different conditions, it may make an excellent evaporative showing.

It is not necessarily the coal which contains the greatest number of heat units per pound which will give the most economical and satisfactory results as a steam boiler fuel. Nor is it the fuel which will show the greatest number of heat units per dollar of cost which is the best to use. In the selection of a grade of coal, use that which will give the greatest amount of evaporation at the least cost in the boilers where it is intended to be used. The generation of steam is the sole province of the boiler, and the more cheaply a given amount of steam can be produced, the better the economy of the boiler as an apparatus and the better pleased is the owner.

There are three ways of determining what a fuel is worth as a heating element, and each has its application as well as its limitation. The first is based on a chemical analysis of the coal, the analysis being quantitative and giving the exact percentages of the various combustible and noncombustible elements in the fuel. Having these, it is an easy matter to calculate the heating value of the fuel. For it has been found by repeated experiment that a pound of carbon will yield 14,600 heat units per pound when completely burned, and that a pound of hydrogen will develop 62,000 heat units in burning. Consequently the heat units in a pound of fuel is readily calculated by the use of the formula.

$$\text{B. T. U.} = 14{,}600\,C + 62{,}000\,(H - \tfrac{O}{8}).$$

In this expression, C, H, and O represent the percentages of carbon, hydrogen and oxygen, respectively, as shown by the

analysis. This formula does not take into account the sulphur which may be present, especially in soft coals, for the reason that its amount is small and it would make no great difference in results. The reason for subtracting one-eighth the percentage of oxygen from the hydrogen is that when the hydrogen is burned it unites with oxygen in the proportion of eight pounds of hydrogen to one of oxygen. That is, one-eighth the weight of oxygen is the weight of hydrogen which combines with it. There is always a small percentage of oxygen in a fuel, and this oxygen will combine with eight times its weight of hydrogen. So that the amount of hydrogen available for combustion is less than that shown by the analysis by an amount equal to the percentage of oxygen divided by eight.

The second method of determining the value of a fuel is by the use of a fuel calorimeter. The calorimeter is an instrument by which a known quantity of the fuel is burned in contact with pure oxygen, the combustion occupying a very short time, and the heat generated being determined by the rise in temperature of a known quantity of water surrounding the combustion chamber, this water absorbing all the heat generated.

The third method of determinng the heating value of the coal is to make an actual test of it by means of a boiler trial and noting the evaporation obtained. This, however, is only a comparative method and not a quantitative one, inasmuch as there are heat losses which cannot well be measured.

The first two methods agree fairly well in results, the difference being as small as three per cent. in some cases, though it is commonly larger. But there is little or no agreement of these methods with the actual results obtained in a boiler trial. In other words, the boiler trial shows considerably less heat derived from each pound of coal than is indicated either by the calorimeter or by the calculations based on the analysis. As a consequence, neither of these two methods can be relied upon to show the actual value of a fuel under any and all conditions.

There are good reasons why this should be the case. Consider the chemical analysis, for example. Here we divide the coal into its component elements and learn the exact amount of each. Then, on the assumption that perfect combustion takes place, the heat value is calculated. Such an assumption is contrary to all actual practice. There has never been a boiler furnace built in which the full heat of the fuel has been set free, and so it is not to be wondered at that actual and theoretical results should differ so markedly.

In the case of the calorimeter, oxygen alone is supplied, without admixture of nitrogen or moisture, which is not the condition that obtains in a boiler furnace. The combustion is exceedingly rapid and complete, and these conditions likewise differ from the actual. Therefore a difference in results may be expected.

Furthermore, in both of the above cases, the sample which is analyzed and the sample which is burned in the calorimeter represent but a very small portion of the entire mass of fuel. The crushing and quartering and sieving of the sample cannot but change the moisture which it previously held in combination, so that while the amount of combustible matter may remain the same, yet in all respects the sample is not the same, nor will it act the same, as the coal fed into the furnace.

It is not intended to disparage the value of the chemical analysis or of the calorimeter test. Both of them are of service to the engineer and may give him much valuable and interesting information. But they cannot be altogether relied upon to furnish conclusive data regarding the use of a fuel under certain given conditions, since the action of the fuel during combustion is under wholly different circumstances in the two cases.

For example, let us suppose that an engineer was in doubt whether to use anthracite or bituminous coal under his boilers. Let us further assume that he could obtain either, at the same cost per ton. Let the anthracite be high in fixed carbon and the bituminous rich in volatile matter. Now, from an examination of the formula for heating value, there is about four and a quarter times as much heat in a pound of hydrogen as in a pound of carbon. Hence it would not be surprising to find that the bituminous coal, with its higher percentage of hydrogen, should give a greater calculated heat value per pound than the anthracite.

Now, if the bituminous gave more heat for the same money, the natural conclusion would be to use it in preference to the anthracite. But this is not the sole consideration. It is possible that in actual trial the anthracite would give far better results in evaporating water than the bituminous, for the reason that the furnace design affects the actual results to a great extent.

It is well known that smoke losses by incomplete combustion are due to the improper construction or operation of the furnace of the boiler and such losses are most likely to take place in those instances where the fuel contains much gaseous matter. Great care is necessary in the burning of soft coal to prevent incomplete combustion and the formation of smoke. The most successful furnaces for the burning of coals rich in volatile matter are those in which ample provision has been made for a high furnace temperature as well as for the admission of air to the combustion chamber.

If a fireman is fairly careful and the volatile hydrocarbons do not exceed more than about one-sixth of the fuel, such coal can be burned in almost any kind of ordinary furnace without the formation of smoke or undue losses. But it has come to be generally accepted that the average boiler setting is not conducive to good results in the use of a bituminous coal rich in hydrocarbons, say 25 per cent. and over.

Therefore, in selecting a coal, the engineer should keep in mind the construction of his furnace and endeavor to obtain a variety suited to the existing conditions. And here is where the chemical analysis will aid him, for it will tell him quite accurately the composition of each variety under consideration and thus enable him to judge as to how well his furnace is adapted to burning each particular type, or what changes would be necessary in case he should wish to burn a softer and more volatile coal.

He must also observe the relative amount of noncombustible matter, or the ash, and it would be well if the analysis would tell him the composition of this ash. For in the cheaper grades of coal the ash often becomes an important consideration. The inferior coals may contain noncombustible, which, under the effect of the heat in the furnace, will fuse into slag and collect as clinker and cause no end of trouble. Such a fuel makes it difficult for the fireman to maintain a clean fire, since the slag will fill up the grate openings and cut off the air supply. It will likewise clinker to the furnace walls. And in removing it from the grates and walls there is no in-

considerable wear and tear on these parts, to their detriment and rapid destruction.

Again, there is the question of the disposal of this refuse after it has been taken out of the ash pit. If the plant is located in the country, where a convenient dumping ground costs little or nothing, the problem solves itself. But in the cities, where no such simple solution is possible, it becomes necessary to transport the refuse from the plant, at some cost. The greater the percentage of ash in a fuel, the greater the cost in disposing of the refuse. This must be taken into consideration in the selection of a fuel, the percentage of ash being readily obtained from the analysis. So, although the calorimeter and the chemical analysis may serve to give a comparative estimate of the actual heating value of different fuels, yet it is by all odds the most conclusive and satisfactory to make an actual evaporative test under the given conditions, where possible to do so, to determine the fitness or the unfitness of a certain grade of steam coal.

Gravitation and Centrifugal Force

In ancient times the earth was supposed to be the centre of the universe, and the sun, moon and stars revolved around it every twenty-four hours, until the great astronomer Copernicus established the Copernican theory, that the sun was the centre round which the solar system revolved. Sir Isaac Newton, by observing the fall of an apple, and from which simple incident worked out the theory of the law of universal gravitation, which balances the centrifugal forces exerted by each body of matter. Gravitation is looked upon as a mysterious force and endless guesses are made as to the particular point or centre of the universe to which all bodies are gravitating.

We cannot grasp the bounds of space, it is an endless expanse, it has neither height, depth, length nor breadth, therefore, *it cannot possibly have a centre.* Bodies of material substance float in its fathomless regions in countless numbers and in an infinite variety of condition as solids, fiery liquids, and incandescent gases. There can be no central body of matter to which all matter is gravitating. Were it so, the universe would inevitably come to an end, all matter would become one solid mass, leaving space an absolute void.

Motion is perpetual as regards the universe. It was, is, and ever will be.

Gravitation certainly does exist but not as a universal force excited by a central sun, as generally supposed. Our centre of gravitation is the sun, the same rule applies to all other solar systems; each system having its central point. Let us examine the condition of space or the interstellar medium. I have frequently referred to it, as being a magnetic field, an ether-adamant, intensely cold and as being inert. It is to all intents a solid vacua, exerting a compressive force upon all matter, pressing upon each body with an energy, which we cannot comprehend, yet that very force contains in itself the elementary force that maintains perpetual motion. *There is as much energy in cold as there is in heat.*

Professor Fiske at Harvard University in 1900 in his address stated:

"Within the past century the study of light, and other radiant forces, has furnished us with a suggestive object lesson. The lumineferous ether combines properties which are inconceivable in connection. How curious to think that we live and move in an ocean of ether, in which the particles of all material things are floating, like islands. But how amazing to learn that this ocean of ether is also an adamantine firmament. Is this not sheer nonsense? An ocean firmament of ether-adamant! Yet such seems to be the fact, and our philosophy must make the best of it."

Gravitation is the result of two opposite forces the sun's centrifugal energy opposed by the planetary centrifugal forces, rotating as they do, from West to East.

If the planets rotated East to West, the sun's energy would cause them all to fly from it into outer space, the solar centrifugal energy would thus coincide with the planetary centrifugal forces, no retardation or reaction upon each other, our solar system would vanish as a vast nebulous cloud melted by friction against space.

This is not an impossible hypothesis, the celestial machinery like our dynamos and other engines can be reversed.

Under present conditions the sun and planets are opposing their centrifugal energies; mutual retardation is the result. The planets are slowly losing their motion, drawn nearer to the centre, the sun itself is slowing down, and will eventually stop.

The solar system will then be a group of dead worlds falling upon the central sun, drawn to it by magnetic attraction, with tremendous violence, sufficient to break up the whole mass into fragments, and resolving into the dust from which they came.

Gravitation now ceases, the solar system is a vast cloud of cosmic dust, each atom is fired by friction and collision. The original cloud of nebulous vapor is all that is left of the glorious sun and planets.

But this does not mean that the other solar systems have also dissolved. Their turn will come sooner or later; in the meantime other systems will again emerge from the chaos and void.

Each group of bodies, revolving round its sun, is an independent system, each occupies its own plane, or position, in an adamantine ether, which has no top, bottom nor sides.

We will now discuss what our earth teaches us, as to the nature of gravity, that force which gives the atmospheric pressure of 14.7 lbs. per square inch.

Our globe as described above is an island floating in an ether-adamant, which exerts a tremendous force of compression upon it.

This compressive force is counteracted by an expansive energy generated by the earth's internal heat, which produces a temperature sufficient to gasify oxygen and nitrogen, forming the atmosphere, also to maintain the liquid ocean of hydrogen and oxygen forming our oceans, seas, lakes and rivers.

The earth's centrifugal force would throw these atmospheric and aqueous oceans into space, were it not for the compression of the ether-adamant, which tends to freeze both air and water, and force it upon, and into, the earth's mass.

Gravity is, then, the result of compression from without, and expansion from within, two pushes and never a pull.

The centre of the earth cannot be the centre of gravity.

Centrifugal force means flying from the centre, therefore, the earth is comparatively hollow. This is proved by the following experiment:

Take a globe and arrange so that it can be turned rapidly on its axis, then fill it about two-thirds full of water, close up the aperture, then turn rapidly, it will be found that the water is

forced to the outer circumference of the globe, leaving the centre free from water.

The water is pulled from the centre and under the rapid rotation it is also drawn from the top and bottom and clings to the sides.

The earth is like that globe, but partly filled with molten metal and rocks, which ever seek an outlet against that force of gravity which we imagine is centred in the interior of the globe.

Our earth spinning round on its axis, exerts a centrifugal force pulling outward from the axis, urging the liquid fiery mass towards the equator, the poles are flattened as a consequence.

The poles are the two points of attraction in the sense of magnetic influence.

Meteors or shooting stars are constantly falling upon the earth; it is a remarkable fact, which, however, has escaped general observation, that meteors invariably fall on or near the poles and pursue a southwesterly course towards the equator in the northern hemisphere, northwest in the southern. If the earth encounters them on the equatorial plane they are thrown off by centrifugal force as in the November showers.

This tends to prove that the poles are the only points by which smaller bodies are attracted to each other.

Gravity and gravitation are thus mechanical forces exerted by every body of matter in the universe acting and reacting upon each other. Each body exerts a centrifugal force which, as in the instance of our solar system, every planet rotating from West to East also revolves round the sun from West to East, their centrifugal energies are contrary to each other, and to the sun. The sun's pull is counterbalanced by the pull of the planets, and as before stated these two pulls can be converted into pushes by a reversal of the machinery of the Heavens.

This is a prime necessity to account for the conservation of energy and to thoroughly maintain a balance between the great law of universal gravitation which must operate positively and negatively, and thus maintain perpetual motion. A watch spring, wound up, exerts centrifugal force; when that ceases, it requires winding up again. So does the mechanism of the universe automatically wind up the actuating energy in each system of suns and planets.

Expansive heat and contractile cold perpetually oppose their forces in a never ending struggle.

The moon is held in its position by the earth's repulsive centrifugal force, it is a dead world and should, according to general theory, fall upon the earth by gravitation. It will eventually collide with our globe when it, also, ceases its motion. Many wild guesses crop up in sensational papers as to the effect of the earth falling into the sun or the moon grazing our earth. These ideas are the outcome of our not understanding the law and operation of gravitation.

Another generally accepted hypothesis is, that the sun is the source from which we derive our heat and life. My contention is exactly the contrary. The sun's gravitative attraction is slowly but surely hastening the end of our globe and also in turn by reaction of the planets nearing its own extinction as a bright shining star.

Each globe, in the ether-adamant or magnetic space, is its own source of heat and life, it runs its allotted span of existence and returns to its original cosmic dust, to rise again as a new star, or sun, reforming again into a habitable world, again into a moon, this operation is repeated in an endless chain of sequences.

In concluding this article, it will not be out of place to explain the atmospheric circulation, which is dependent upon centrifugal force and its complement, centripetal tendency.

The poles of the earth are flattened, because the original state of our globe was a molten liquid, as it cooled its centrifugal force caused a bulging outwards of the equator, and depressed the surfaces at the poles by centripetal force.

The atmosphere is an elastic gaseous sphere. It is flattened at the poles in a greater degree than the solid crust. The earth's centrifugal forces draws every particle of air from the immediate vicinity of the polar regions, leaving two airless regions, covered by perpetual ice. Arctic explorers have reached about 84 degrees latitude, the temperature observed about 80 below zero, or 112 Fahr. I venture the assertion that this is the utmost limit, that within this zone there is no atmosphere.

The air is nonexistent, because the earth's internal heat is absent, and unable to resist the compression of space; and the centrifugal tendency impels the air towards the equator in the form of a huge spiral or cyclonic wave, as North and Northeast trade winds, in the Northern Hemisphere, and South and Southeast counter trades in the Southern.

These two great polar currents meet at the equator and are forced upwards, and return as the constant upper poleward winds above the line of perpetual frost, 16,000 feet above sea level The watery vapor held in suspension becomes frozen and in its course towards the poles every mountain range is coated with a constant stream of minute ice and forms the great glaciers, constantly fed by the atmospheric frozen stream of vapor.

The snow line dips down lower, as it nears the poles, eventually reaching the sea level, the atmosphere deposits all of its frozen vapor, unable to carry it further.

The poles are thus the final depository of the frozen moisture and the polar ice is forced away by its increasing weight and centrifugal tendency, aided by the ocean currents which convey it towards the equator, as huge icebergs, which melt as they float into warmer regions. Evaporation increases and again by condensation the great ice stream is constantly renewed.

Is not this a wonderful illustration of the combined forces of gravitation and centrifugal force, and in a simple manner explains the mechanical operation of the mysterious force which science has vainly endeavored to explain, its very simplicity has eluded their profound calculations.

It is, however, admitted that electromagnetism is intimately connected with gravitation, and balanced by centrifugal energy.

Now they are puzzling over the new substance Radium, and its radio activity. Is it not due to atmospheric electricity, which it has a particular affinity for, just as steel has an affinity for magnetism by its power of absorption?

The source of all our energies, gravitative, electric, magnetic, steam, water, and wind power, is due to and proceeds from one everlasting source—the ether-adamantine ocean of electro-static space.

This solves the great problem of the natural forces of electricity, gravitation and its endless manifestations as purely mechanical energy.

A. G. WILLIAMS.

The Origin and Value of High-Pressure Steam

The present is the era of high-pressure steam and it is used by nearly all engines with any pretensions of economy. It is not unreasonable to expect still higher pressures in the future, and to be able to clearly comprehend the advantages and disadvantages of such pressures we must reason from the increase in the past; and from the lessons taught by experience with them, anticipate the results of future work.

It is probably in naval work that the steady rise of steam pressures can be most easily noted. In the steamships of about sixty years ago, four pounds represented the ordinary practice. It was generated in the so-called "flue" type of boilers, the tubular type not coming in until about 1845, when the steam pressure in seven or eight years rose to from ten to twelve pounds. By 1860 it had reached a maximum of twenty pounds. At this time the introduction of surface condensers took place and thus allowed the use of still higher pressures, so that by 1870 they had reached thirty pounds.

Until the adoption of the surface condenser, they were all of "jet" type; that is, the steam to be condensed was thrown in contact with a jet of salt water and the mixture used for feeding the boilers, although it was nearly as salt as the sea water itself. But, with the introduction of the surface condenser, all this was changed, and from then really dates the later and rapid rise in pressures. For in this type of condenser, the condensing water is kept entirely separate from the steam to be condensed, thus enabling the boilers to be fed entirely with fresh water, utilizing the heat of the condensed steam, and making the increased steam pressure possible without danger of over-heating the boiler plates because of the incrustations of lime and other salts which invariably follow the use of salt water in boilers. In fact, many of the beneficial results following the use of high pressures would not have materialized had not the surface condenser been brought into use.

These jet condensing engines were always of the simple expansion type and of very low economy, as only a very small expansion took place and the gain therefrom was in consequence very low and the coal consumption per indicated horse power very high.

When the pressure, however, reached thirty pounds the expansion principle was carried out to a much greater extent, and this increase in the rate of expansion necessitated an increase in the size of the cylinders.

There can be no doubt but that expansive engines with steam of thirty pounds pressure, steam-jackets, superheaters, and surface condensers were fairly economical, and marked a great step in advance over those immediately preceeding them.

There is no doubt but that just at this point the birth of our modern engineering took place, that preceding having been but the embryo. Attention having been directed to higher pressures and the desirability of increasing the economy of the steam engine, the utilization of the expansive properties seemed to promise the most glowing future. In consequence, the pressures rose immediately from thirty to sixty pounds and the type of boiler was changed to the cylindrical form, the better to safely meet the increased strain. Simultaneously the compound engine came into use. In this type the steam is first passed into a small cylinder, and at the end of the stroke in that cylinder, it passes into one or more larger ones before reaching the condenser where it is condensed.

There were, of course the usual arguments among engineers as to the advantages of these changes, and there was some trouble with the first applications of this compounding principle, but it soon proved to be the right thing, and with little change, is used to-day.

What was the principle reason for these successive steps in the increase of steam pressure? It was due to the gain in economy. This gain was considerable, amounting to thirty per cent., in compound engines using steam of sixty pounds, over the best type of simple surface condensing of that date. A summary of the advantages due to the use of the compound engine would be as follows:

First. A more regular turning movement and consequently increased efficiency of propellors.

Second. Lessening of maximum stress on engine parts and reduction of cost in consequence.

Third. More economical use of steam through expansion with greater return from same number of units of heat in the coal.

From about 1872 to 1880, the steam pressures increased to ninety pounds, the ratios of expansion increasing proportionately. By 1887 the pressure had increased to 160 pounds. When the pressure had reached 120 pounds, the triple-expansion engine began to be fitted into war vessels. In this type the steam is passed into each of the three cylinders consecutively and is finally exhausted into the condenser. This type was and is an undoubted success; and it is now almost universal in first-class ships. The gain in economy has been variously estimated, but the general conclusion is that it is about 15 per cent. over the compound two-cylinder engine using the same pressure.

During the past ten years steam pressure has jumped tremendously. The triple-expansion engine uses steam at 180 pounds, and the quadruple expansion at from 225 to 300 pounds. The quadruple-expansion engine is a four cylinder compound in which the steam is expanded successively in each of the four cylinders before being exhausted into the condenser. Steam of 300 pounds pressure is generally used on torpedo boats, destroyers, and small yachts.

Because of the room athwartship taken up by the low-pressure cylinder of the modern triple, or quadruple-expansion engines, it is usually divided into two cylinders, thus making a 4-cylinder triple and a 5-cylinder quadruple; that is, each type has two low-pressure cylinders. This also gives a better balanced engine and gets rid of the very heavy low-pressure piston by dividing it into two pistons, the sum of the two weighing less than a single large one.

From a steam-engineering stand-point the single cylinder is the most economical method, as with two cylinders the condensing surface is greater with consequent greater loss by condensation. In fact, the best engine would be a single cylinder, taking steam at a high, and exhausting at a low pressure, thus getting all the expansion in one cylinder, but this is impracticable. When pressures of 120 to 150 pounds were reached it was up to the limit of the boilers, and the Scotch, or return-tubular, boilers came into use. They were safe, easy working, and durable, and are to-day the best type for pressures up to 180 pounds. Above that it is an open question if they can compete with the water-tubular type. The return-tubular boiler consists of a cylindrical shell containing one or more circular furnaces, usually corrugated, leading

and opening into a combustion chamber, and from this combustion chamber very small tubes lead back to the front of the boiler. The operation is as follows: The hot gases given out by the heated coal pass to the combustion chamber where they are mixed, and recombustion takes place. From thence they are conducted through the small tubes to the uptakes. The majority of the heating surface consists of this small tube surface. In the water-tubular type, the water is in the tubes and the heat plays around and between them. The gain in mean effective pressure increasing from 90 to 150 pounds is one-third greater than, and by increasing from 150 to 200 pounds is about equal to, that obtained by increasing from 60 to 90 pounds. The gain is 9 per cent. at 210 pounds and 14 per cent. at 250 pounds, and over 18 per cent. at 300 pounds. These increases are worth obtaining if they can be obtained without serious difficulty or increase in machinery weights

As to sources of trouble due to the use of high-pressure steam, they may be classed under two headings.

First. That due to the actual increased pressure.

Second. That due to the higher temperature.

The stresses due to the high pressure can be easily calculated and dealt with, as with the improved materials of to-day we are not yet near the limit of working stress.

From careful experiments made regarding the effect of high temperatures on the various metals and alloys used in engineering construction, it has been found that they make but little difference. These experiments were made at Portsmouth under the direction of the engineer in chief of the English Navy, with the following results:

For mild steel up to 800° F. there was no appreciable decrease in strength. At 400° corresponding to steam pressure at 235 pounds, the loss in strength of gun metal averaged from 10 to 20 per cent. For a composition of 88 per cent., copper, 10 per cent. tin, and 2 per cent. zinc, the loss was from 10 to 15 per cent. The presence of lead makes the castings unreliable. The decrease in strength for the temperature of 400° in other metals is as follows:

Naval brass	5 per cent.
Ordinary copper	7 per cent.
Manganese bronze	8 per cent.
Compressed copper	11 per cent.

The increase in the temperature of the boiler shell, due to the temperature of the steam would average about 122° above the steam temperature.

In regard to coal consumption the following is taken from Mr. H. J. Oram's report of the Admiralty Committee on five hundred trials of fifty-one ships:

All the trials were of more than twelve hours' duration under ordinary service conditions in all parts of the world with coal of ordinary quality.

Taking 6 per cent. of the full power as the basis of comparison the consumptions were as follows:

	Lb. coal per H. P.
60-lb. pressure compound engine	2.8
100-lb. pressure compound engine	2.45
140-lb. pressure triple expansion engine	2.21

It will be seen that the saving is about 12½ per cent. in one case and 21½ per cent. in the case of the triple compound of 140 pounds. A comparison of these figures with the theoretical gain shows that they are equivalent to about 90 per cent. Putting these experiments in the shape of curves, it is found that we may calculate on a saving of 12½ per cent. for 250 pounds as compared with 150 pounds pressure.

A Mid-Summer Ice Formation

A Scientific Puzzle

That tons of ice should form in a mine, or cave, on the hottest days of summer, the greater the heat the greater the amount of ice, and gradually disappear as cold weather approaches, until not a trace of the ice is to be found in winter, seems contrary to all natural laws. This, however, is what happens every season at the Sweden Valley Ice Mine.

The mine is situated half way up a heavily wooded slope, just south of the little hamlet of Sweden Valley, and five miles from Coudersport.

It is reached by a narrow fern bordered road, where green branches form an archway overhead, sweeping the face of the passer-by.

One summer day, several years ago, a resident of the "Valley," prospecting for minerals, found the crevices of the sandstone ledges which crop out on the hillside, filled with ice, which he noticed formed again as soon as removed. He reported his discovery to the owner of the land, John R. Dodd, who proceeded to investigate the matter further by digging into the hill latterally to the distance of fifteen feet, then sinking a six-foot shaft to the depth of eighteen or twenty feet.

As the days grew warm large quantities of ice formed in the shaft. News of the phenomon spread abroad, and visitors, not too incredulous to believe the story, flocked to see this strange freak of nature. So many people came and so much of Mr. Dodd's time was taken in exhibiting the mine that he erected a building over the entrance and began charging sightseers a small fee for admission.

Scientists from different parts of the United States and from Europe have visited the mine, but as they fail to agree, no satisfactory explanation of the phenomena has yet been made. The hill is largely composed of micaceous sandstone and shale, the strata of the sandstone being very loose. In excavating, boulders resembling petrified trunks of trees were found. Many specimens of these may be seen on the grounds. Scientists say they are not trees, but clay rolled and folded over by pressure and movement of the surrounding rock. However, this may be, they are as neatly molded as a baker's roll.

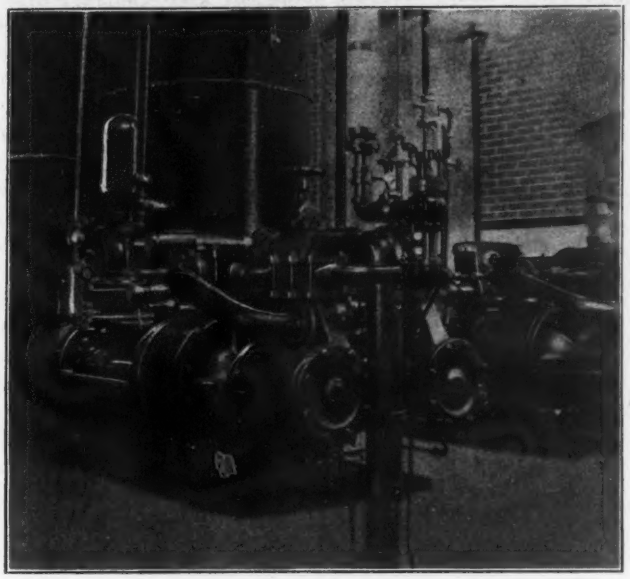
Before entering the mine it is necessary for the visitor to put on extra wraps, for the mist constantly arising from the shaft chills the visitor to the marrow. The rocks in the cave drip with moisture, which is constantly congealing, if the weather is sufficiently hot, filling the rock crevices with glistening ice. In the shaft below great masses of dull grey ice accumulate, while icicles from six to eight inches thick hang from the projecting ledges like stalactites in a cave.

On a recent visit to the ice mine, it was found that a descent of the shaft was impossible, the steps and ladders being so heavily coated with ice as to resemble toboggan slides. When removed the ice formed again so rapidly that all attempts to keep the steps clear had been abandoned.

Power Plant of the Bartlett Building, Atlantic City, N. J.

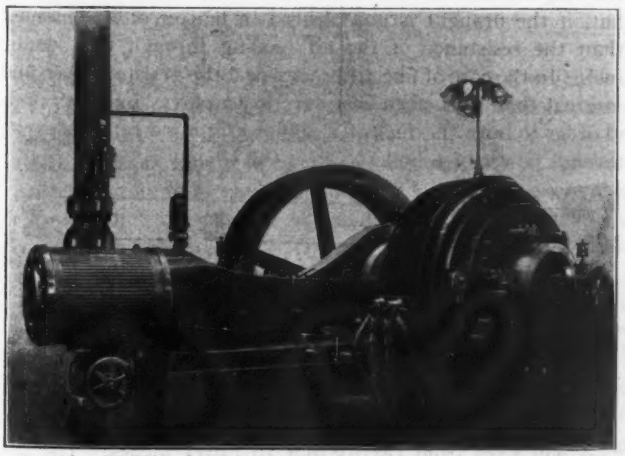
The accompanying illustrations show the engines and pumps of the power plant in the Bartlett Building, Atlantic City, N. J. This building is probably one of the finest constructed office buildings to be found anywhere in the country, and is a credit to the enterprise of Atlantic City's business men.

The interior work throughout the entire building is the finest Tennessee Marble. The mechanical equipment is in keeping with the plan that everything must be of the best.



The elevators, three in number, were installed by Morse, Williams & Company, Philadelphia, and are of the hydraulic type with upright water pistons. The signal system used is of the flash-light type.

In the third floor of the building the chief engineer has his private office, which is in itself a mechanical work of art; facing his desk is a complete equipment of clocks, gauges, etc., each recording the working of the machinery in all parts of the building. The installation of the entire plant has been under the very able supervision of the chief engineer, Mr. B. F. Vanderslice.

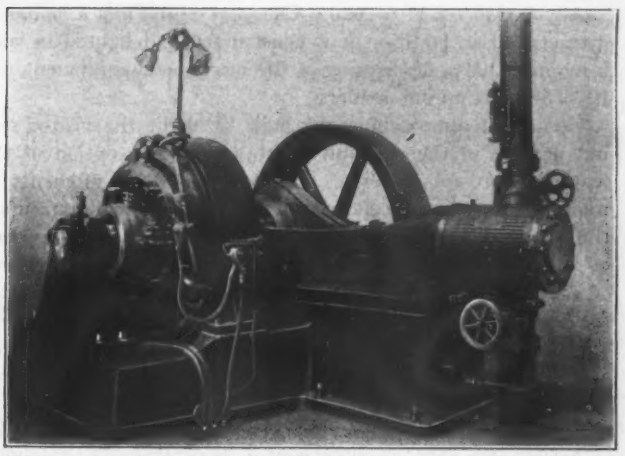


In the roof of the structure there is placed two centrifugal fans for the purpose of keeping up a circulation of pure air throughout the offices, and also for discharging the foul air.

In the engine-room will be found two Ames engines, built by the Ames Engine Works, both of which are shown in the cuts. These engines are 14″ by 14″, making a speed of 275 revolutions per minute and are direct connected to two electric generators of 75-kilo watts each. The electrical instrument equipment was manufactured by the Weston Electrical Co., Newark, N. J., and was installed by J. F. Buchanan, Philadelphia, electrical engineer. The heating system is of the Warren Webster pattern vacuum system installed by the Warren Webster Company, Camden, N. J. Also the feed water heater of 300-horse power is from the same company.

The pumps are of the compound duplex type of Worthington make, 10″ by 16″ by 8½″ by 10″. In addition to this there is a high duty Worthington pump of 6,000 pounds lifting capacity to use in the hoisting of safes or other heavy material in the building.

The boilers of the Coatesville return tubular make, three in number, 18″ by 72″, containing each 78-four-inch tubes rating at 150-horse power each. A commendable feature of the plant is a five-inch auxiliary steam line which can be thrown into operation entirely independent of the main line in case of accident. The steam pipes are covered throughout with nonpareil cork and present a very neat appearance. There is a coal storage bin of ninety tons capacity within easy access. Upon the boiler feed pumps are Ford pump regulators.



The number of lights throughout the building are 2,400, lighting 235 offices, nine stores and sixteen dwelling houses, which are also heated from the main plant. Taken as a whole the building surpasses anything of its kind in Atlantic City and probably will for sometime to come. No expense has been spared to place it in the front ranks of buildings in every possible detail, the appreciation of which is shown by the fact that the offices are rented as fast as completed.

The Pressure of the Sea

There are spots in the ocean where the water is five miles deep. If it is true that the pressure of the water on any body in the water is one pound to the square inch for every two feet of the depth, anything at the bottom of one of the "five mile holes" would have a pressure about it of 13,200 feet to every square inch. There is nothing of human manufacture that would resist such a pressure. That it exists there is no doubt. It is known that the pressure on a well-corked glass

bottle at the depth of 300 feet is so great that the water will force its way through the pores of the glass. It is also said that pieces of wood have been weighted and sunk in the sea to such a depth that the tissues have become so condensed that the wood has lost its buoyancy and would never float again. It could not be even made to burn when dry.

Lighting Plant at Chestnut Hill Park, Phila.

Almost every large city has one or more suburban pleasure parks, but in this line Philadelphia, Pa., excels all other cities in the world with the exception of Paris, France. The topography of the country immediately surrounding the "City of Brotherly Love," being largely conductive to this condition. Combined, also with the very liberal patronage bestowed upon such projects by the people in general.

Upon the front cover of this edition of THE PRACTICAL ENGINEER will be observed the picture of an engine of more than usual interest as it is used to supply electric current for one of Philadelphia's most beautiful creations in pleasure parks, namely, "Chestnut Hill Park." The park is situated in that historic valley known as "Whitemarsh," where General Washington and his gallant heroes encamped the winter prior to the "Battle of Germantown," in which, while the Americans were successful in beating the British, they were in such a demoralized condition themselves that they did not know of their success until too late to profit by it.

All of this tends to make Chestnut Hill Park a point to attract, but in addition it is constructed and lighted in such a manner that a description of the mechanical equipment will be of interest to our readers.

Upon first approaching the park by night the visitor sees but a glare in the sky and has but little conception of the feast in store for his eyes. It takes but a few moments to round a curve in descending the hill, and there bursts upon the vision a perfect fairyland of light-myriads and myriads of vari-colored electric lights being distributed over a space of about thirty acres of ground in pleasing confuson. After the first ecstacy of bewilderment is over the engineer will approach the power-house from whence comes all this glory and wonder. A step within will show first enormous Wetherill Cross Compound Engine right and left direct connected to a 550 Kilo Watt Westinghouse electric generator. The engine is of the Corliss type and at full load makes a speed of eighty-four revolutions per minute. It will be noticed in the illustration that only one of the cylinders appears, which is because of the dynamo and fly-wheel being placed between the high and low pressure cylinders. At the further end of the engine-room will be noticed running a pumping engine of the Wetherill type which maintains the vacuum in the condensers.

Steam is furnished the engines and pumps by five Coatesville return tubular boilers each of 100-horse power. The feed-water is obtained from a lake in the midst of the park and reaches the boiler through two compound duplex Blake pumps after passing through a Berryman feed-water heater. Besides lighting the park the current is used to "boost" the cars up over the hills on their return trips.

A feature of the plant is that it is not run continuously, but closes down shortly after mid-night and remains standing until noon the next day. Current meanwhile is supplied for the cars, and for lighting where necessary, from a powerful storage battery situated part way up the hill.

The Relation of Draught to Grate Bars

Grate bars are usually made of cast iron, and consist of alternate supports for the fuel to be burned and spaces for supplying the air needed for combustion. Every portion of the entire area of the grate surface should be made of these alternate "lands" and spaces. The top surface of the grate should be perfectly level, otherwise it will be difficult to properly clean the fire with ordinary hand-tools. The grates must rest upon proper supports, and these must be of such form, dimensions, and so located under the grates as to prevent their warping or getting out of shape by the action of the radiant heat from the fire. The grates should have at least one end free for expansion; otherwise they will get out of shape.

The clear opening through the grates is usually as large and as much subdivided as possible, that each portion of the fire shall have its proper supply of air. They commonly have $\frac{3}{8}$– to $\frac{5}{8}$–inch openings, with only as much lateral obstruction at the ends and centre of the bars as is necessary to enable them to keep their shape. Such a grate is shown in Fig. 1, the metal and spaces being about equally divided. Mr. Barrus's observations are, that "Grates with 50 per cent. air space gave 3.2 per cent. better results based on coal and 1.7 per cent, better results based on other combustibles than grates with 60 per cent. air space.

"The smaller the rate of combustion, the smaller should be the opening for draught through grates. The gain probably comes about by preventing the introduction of too great an excess of air over that required for combustion."

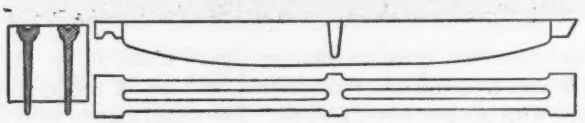


Fig. 1.

The practical spacing for grate-bars for the admission of air will depend on the kind of fuel to be burned. For bituminous coal it may be $\frac{1}{2}$– or $\frac{3}{8}$–inch, but for anthracite coal and especially when burning the finer grades, such as rice, buckwheat, and pea coal, the distance must be less, and may approximate $\frac{3}{8}$–inch in width. The larger the area of opening, the less will be the resistance of the air passing into the fire; but, if the draught is good, this is a matter of less moment than the resistance of the air passing through the burning fuel. In the case of fine anthracite coal this resistance becomes so great that it is often necessary to employ a forced draught in order to burn the fuel at a sufficiently rapid rate to develop the full power of a boiler.

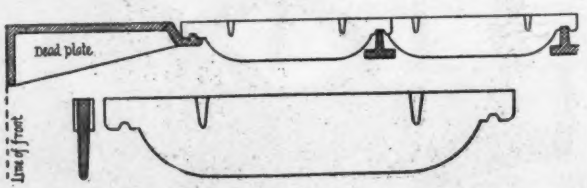


Fig. 2.

The distance for the level of the grates above the fire-room floor will vary from twenty-four to thirty inches. The first is probably the best distance, all things considered; and nearly all fire-fronts approximate this height.

The slope of grate-bars is usually from the furnace front towards the bridge wall in the proportion of about one inch in twenty of the length of the bar. No advantage accrues in this; and for stationary boilers, externally fired, as good results may be had if the grates are set level. Inclining grates to the rear probably originated in marine practice, in order to protect the fireman from live coals rolling out of the furnace when stoking in rough weather.

Grate bars are commonly cast in pairs, as this adds much to their stiffness over single bars, and are thus better able to resist bending and twisting. Cast-iron bars should have a groove on the top along their whole length, as in Fig. 1. This

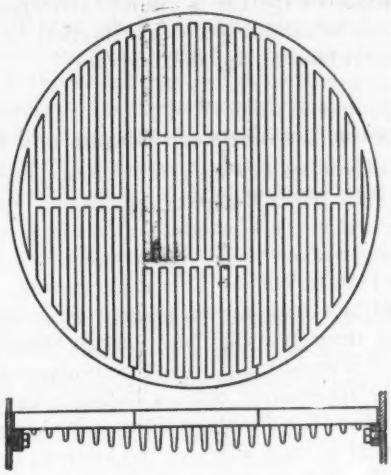


Fig. 3.

groove, filling with ashes, prevents in a measure the clinkers adhering to the grate. Short bars suffer less in distortion by overheating than long ones. Thin and deep grate-bars, such as shown in Fig. 2, give excellent results. The bottom edge should be no thicker than will insure a sound casting. Such bars are usually cast singly and not in pairs. No difference need be made in the construction of grates between anthracite and bituminous coals.

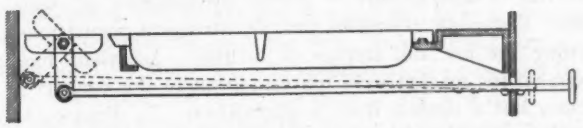


Fig. 4.

A grate for a circular fire-box is shown in Fig. 3, which does not differ essentially from the one referred to above, except that instead of being confined to two or three bars a larger number are included in a single casting. The engraving shows the grate to be made up of three sections. It is obvious, however, that the number of sections will depend upon the diameter of the fire-box. The width of the sections ought not to greatly exceed 12 inches.

A stationary grate with tilting section at the end next the bridge-wall is shown in Fig. 4. This is a very convenient arrangement for dropping ashes, clinkers, etc., into the ash-pit underneath. Grates as long as six feet should be provided with some device similar to this to prevent ashes from accumulating at the bridge-wall, which accumulation has the effect of shortening the furnace and diminishing the grate area.

A herring-bone grate, shown in Fig. 5, is extensively used in this country, its popularity not being confined to any one locality. The angular spacing readily permits expansion and contraction to take place without breakage. It with-

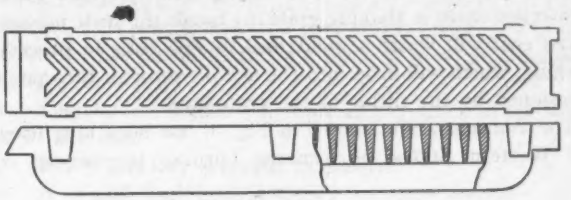


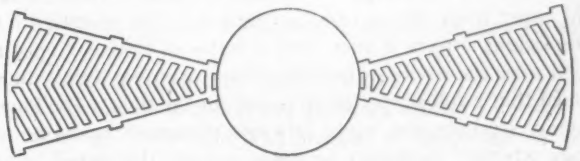
Fig. 5.

stands the effects of repeated heating and cooling quite successfully. An adaptation of this grate for a circular fire-box is shown in Fig. 6.

A revolving grate is shown in Fig. 7. This is a very convenient arrangement for shaking the ashes out of the fire, for breaking up masses of clinker, and for dumping the contents of the furnace into the ash-pit underneath. The two middle grates in the upper row show how this is accomplished; the side bars show how the grates are kept level by locking upon one side wall and then upon each other.

Shaking or moving grates are designed to facilitate cleaning the fires, and, without opening the fire-doors, the removal of loose ashes and clinkers which would ordinarily fall into the ash-pit by the use of a slice-bar, also to break up and loosen the bed of burning fuel if the latter has a caking tendency.

Some very absurd claims have been put forth regarding the great saving in fuel by the use of such grates, but the following extracts from a letter puts the question in a way too



F.g. 6.

often overlooked, and that is in reference to the protection afforded the fireman himself, who asks: "If the doors have to be opened to clean the fires, is there not a loss in the admission of cold air to the boiler, to say nothing regarding the injury to the boiler itself? Again, can any fireman with a slice-bar, no matter how dexterous he may be, thoroughly stir out the ashes from every part of the grate, and if not, is not the supply of air to that extent cut off? If a fireman

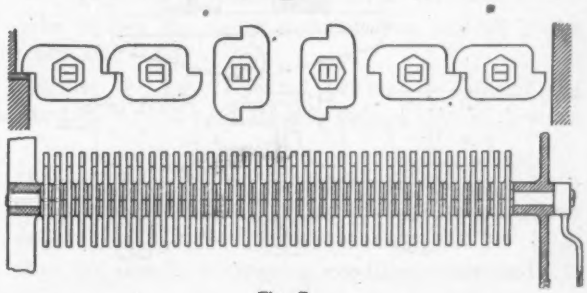


Fig. 7.

can, with comparatively little effort and without exposure to intense heat, thoroughly clean every inch of his grate by using the shaking-grate, why, in the interest of humanity and economy, should he not be furnished with one?"

Shaking-grates will break up a bed of non-caking coal or anthracite coal very satisfactorily, but they do not always succeed in breaking up large masses of coal which may have fused together because of its caking quality. The fireman who relies upon a shaking-grate to break up such masses of caked coal will waste a great deal of fine coke in process of burning, which will drop into the ash-pit through the openings occasioned by the tilting of the grate-bars.

The Butman grate, shown in Fig. 8, has been long used in the Western States in furnaces burning bituminous coal.

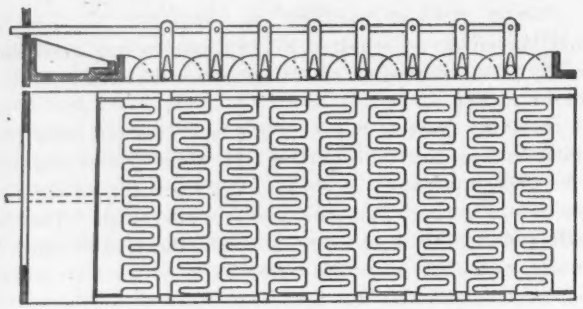


Fig. 8.

The grate is exceedingly simple and very effective; it consists of two side-bars notched to receive the grates, which are provided on their upper surface with oblique cutting edges and interlocking fingers, which also form parallel cutting edges. The cross-bars to which these interlocking fingers are attached are corrugated in the direction of their length, and taper from the top to the bottom. The spacing of the interlocking fingers is such that a series of irregular openings occur over the whole surface, and these openings are so dimensioned that a full supply of air is had for the fuel. The fingers, having semi-circular ends, always preserve the same distance whether stationary or being rocked, this detail of construction preventing the loss of small fuel by its falling through into the ash-pit when cleaning the fire. Each rocking-bar has an arm projecting downwards, attached to a connecting bar operated from the front of the furnace. When the fire

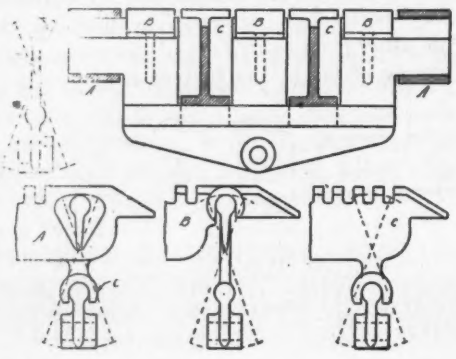


Fig. 9.

is being cleaned by this rocking motion the whole surface is broken up at the same time, any accumulation of clinker being prevented by the cutting action of the locking fingers.

A shaking-grate known as the Ætna is shown in Fig. 9. Upon ordinary bearing-bars, common to all furnaces, are laid two or more stationary bars, A (depending upon the width of the furnace). Near either end is an opening, shown in one of the detail drawings, in which are placed two rockers. These spring freely like a scale bearing upon pivoted edges. Upon these rockers are placed the moving bars, B and C. When at rest the grate-bars present the same level surface as an ordinary grate. Attached to the front rocker is a socket, shown in the two upper drawings, which reaches almost to the ash-pit door. A lever put in this socket and worked imparts to both sets of bars at the same time a vertical and horizontal movement over the entire surface. By this action the entire surface of the fire is cleaned and opened, a condition which can be maintained with little effort by one or two movements of the lever at periodic intervals.

Transmission Loss Between Niagara and Buffalo

Naturally all who inspect the great central power station of the Niagara Falls Power Company, at Niagara Falls, become greatly interested in the wonderful feat of transmitting thousands of horsepower over solid copper and aluminum conductors from the Falls to Buffalo. For many persons it is difficult to understand how such a vast amount of energy is transmitted over or through a solid body such as these conductors. and people often wonder as to what percentage of the power designed to be transmitted reaches Buffalo. In other words, they wonder what the percentage of loss is in the transmission.

For the benefit of those who seek this information, it may be stated that the loss of energy in the transmission is less than twenty per cent. This is equivalent to saying that of the energy present on the Niagara end of the transmission lines over eighty per cent. reaches Buffalo and is available there for light, heat, and power purposes.

Progress in Illuminating

In this country the novel illuminant is the Nernst lamp. Abroad it is the acetylene lamp. The Continental papers are full of descriptions of public installations of acetylene. Most European countries provide stringent regulations governing the use and storage of carbide. Acetylene has now been on the market fully ten years, but in this country it has found but a modest field of application. In France, Austria and Germany, however, there are many public and private acetylene plants. One interesting little plant at Zinkau, in Austria, has been in operation for five years, and is reported to have given no trouble whatever. It regularly supplies about 1000 lights, including lamps on the highways, in the public parks, hotels, apartment houses, chapels, and, curiously enough, in an old fifteenth century castle.

Reverting to the Nernst lamp, its adoption by public and private plants throughout this country, during the year it has been on the market, has been simply phenomenal. According to the very best authorities upward of 1000 plants have already been equipped in whole or in part with it. The Hartford plant was the first station to adopt it on an extensive scale, and this progressive little Connecticut town has about 4000 Nernst glower lamps in use. It is asserted that the same illumination can be secured as with incandescent lamps, at about one-half the cost. The lamp is being introduced into factories, halls, office buildings, banks, etc. A number of the

large manufacturing concerns in the neighborhood of Pittsburg have recognized its advantages and many of the packing houses of the West are using it in their stock yards. For drafting work it is said to be greatly superior to the incandescent lamp, being uniform and steady, and of a specially desirable color. The city of Oshkosh has recently adopted this style lamp for street lighting.

Acetylene is being adopted on the street sweepers used in Hamburg. Street cleaning in Hamburg is all done at night, when the highways are comparatively free from traffic, and when the dust incident to the operation is not an annoyance to the public at large. In order that the machines may be as effective as possible they are constructed without springs, to ensure a continuous contact of the rotary brush. The jolting and vibration of any lamp carried on these sweepers is destructive to most types, but the acetylene lamps appear to be quite satisfactory. The lamps resemble those used by cyclists, and carry sufficient carbide for a whole shift. They are carried at the side of the sweepers, and designed like a headlight to throw a powerful beam of light upon the roadway in front of the machine.

The Rating and Speed of Dynamos and Motors

The fact that a machine of a given size has one rating and speed as a dynamo and a totally different rating and speed as a motor always appears to the average student to be inconsistent. The explanation is simple enough. The discrepancy in both rating and speed is due principally to the fact that a given machine is operated at a higher voltage as a dynamo than when it runs as a motor. As the speed is almost exactly proportional to the voltage, it will be lower for the motor than for the dynamo; and as the output is directly proportional to the speed, lowering the latter reduces the former. The current carrying capacity of the machine is practically fixed, regardless of its armature speed; therefore the loss in output due to lower voltage (or the resultant lower speed) when a dynamo runs as a motor cannot be compensated by increasing the current passed through its windings .

For example, a 10-k.w. 125-volt dynamo will have a current capacity of 80 ampheres, plus the shunt field current, say 83 ampheres total. Assume that its speed is 1300 r.p.m. and its armature resistance 0.06 ohm; the drop in the armature will be 0.06+83=4.98 volts, so that the total e.m.f. generated will be 130 volts, or 0.1 volt per r.p.m. Now if the same machine be put out on the circuit as a motor, under an impressed e.m.f. of, say, 115 volts, the field strength will be about the same as before, as there is no rheostat in the field circuit, and when running at full load the drop of practically 5 volts in the armature leaves only 110 volts of the impressed e.m.f. to be balanced by counter e.m.f.; the speed therefore will be 1100 r.p.m. instead of 1300. The machine will receive from the line 86 ampheres (3 in the shunt field winding and 83 in the armature) at 115 volts, or 9.89 kilowatts ,and if it has 88 per cent efficiency, it will deliver the mechanical equivalent of 8.7 kilowatts at the pulley. Its ability as a motor therefore would be a trifle over 11¾ horse-power. This rough example shows why the speed of a machine is always lower as a motor than as a dynamo, when operated on a given circuit, and why its power-delivering ability is also less when operated as a motor than when it works as a dynamo.

Natural Philosophy

Mechanical Properties of Bodies

Question. Is a piece of wood, or a pebble, or an iron bar all solid matter?

Answer. It is part matter and part empty space.

Q. Is there as much matter in a piece of wood as in an iron bar of the same size?

A. There is less matter and more empty space in the wood than in the iron.

Q How is this fact generally expressed?

A. It is said that iron is denser, or more compact, than wood.

Q. What are the empty spaces in the interior of bodies called?

A. Pores. The pores are visible in many substances, for example, in sponge, cork, and some kinds of wood.

Q. Are the pores in the interior of bodies entirely devoid of matter of any kind?

A. The larger visible pores contain air, and the more minute pores, in even the densest substances, contain a very subtile ether, which also fills all space.

Q. Can a body of matter be divided into smaller and smaller parts without any apparent limit?

A. It can. In two ways. Mechanically, that is, by pounding, grinding, etc.; and by solution.

Q. Give an example of the minute subdivision of matter by solution.

A. A grain of blue vitrol, smaller than the smallest pea, will give a blue tinge to half a gallon of water containing twenty drops of spirits of hartshorn. In this half gallon there are 250,000 drops.

Q. Are there any last particles that can not be divided any further?

A. Chemistry informs us that there are.

Q. What are these indivisible particles called?

A. Atoms. Every body of matter is made up of indivisible atoms.

Q. Are these atoms so close together as to be in actual contact?

A. They are not, they always stand apart from each other.

Q. What holds them together?

A. Each particle pulls the others toward it, or attracts them, just as a magnet attracts a piece of iron that is brought near it.

Q. What is this attraction between atoms called?

A. The attraction of cohesion, or simply cohesion.

Q. Why do not the atoms rush together, and all bodies become perfectly solid?

A. Because the heat collected between or around the atoms exerts a repulsion, and keeps them a certain distance apart.

Q. How do we know that heat has this effect?

A. If the heat be increased the particles are forced farther apart, and if it be diminished they draw nearer together.

Q. How are these two changing conditions expressed?

A. By expansion and contraction, or repulsion and attraction.

Q. What have you to say of the forces of attraction and repulsion exerted between the atoms of bodies?

A. That their energy is enormously great.

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The Other Side of the Question

The mechanical stoker has been made the subject of numerous articles in the engineering press, and in all of them the advantages are set forth in alluring terms. But it must not be supposed from this that mechanical stoking possesses no disadvantages, for it does, and these will be briefly discussed.

In the first place, the stoker must be driven by some external agency, and this usually takes the form of a small reciprocating engine, driven by steam or water. This means that the engineer must care for auxiliary apparatus connected with the stoker and keep it in repair if there is to be uninterrupted service. With the ordinary grate no such care or attention needs to be observed.

Again, there are numerous types of stoker in which the moving parts of the grate are subjected to the dust and the grit of the ash pit. Any fireman knows what an amount of fine dust is thrown off from dry ashes, and this dust penetrates to every nook of the setting in the vicinity of the ash pit. Now, in those types of stoker in which the grate is given an alternating or rocking motion, or in which the entire grate surface travels from the front to the rear of the furnace, there are numerous joints and wearing parts, and the dust soon gets into these bearing surfaces and causes friction and wear. It is not feasible to lubricate these parts, for the dust would quickly destroy the best lubricant, while the heat to which the grates are subjected would likewise volatilize any oil placed on the bearings and render it worse than useless.

Several mechanical stokers are in the form of inclined grates in which the alternate bars are given a vibratory motion, the fuel being thus loosened and moved slowly down the incline. In doing this, unless the regulation is carefully watched and adjusted and the grates suited to the fuel ,there is a likelihood of the finer unburned particles of coal falling through to the ash pit, and this is a dead loss. With a stationary grate this is not so liable to occur, since the only thing that could bring it about would be the stirring or raking of the fires.

The mechanical stoker is not adapted to burning any and all kinds of fuel with equal advantage. With the finer grades of anthracite, and with culm, it finds an sepecially favorable field. But if a caking bituminous coal is employed, there is apt to be trouble. For, under the heat of the furnace, the soft coal will fuse on the grates and then it will be necessary to use the slice bar to keep the grates clean and the fires in good condition. This is attended by loss of fuel through the grates, and in this instance at least it possesses little or no advantage over the stationary grate except the saving of manual labor and the obviating of open fire doors.

However, if the advantages to be gained are arrayed against the disadvantages which may be urged, the former will be found to outweigh the latter to such a considerable extent as to prove conclusively the ultimate benefits to be derived from mechanical stoking.

The Man With the Monkey Wrench

The man with the monkey wrench has been held accountable for more serious wrecks to engines and machinery than all other causes put together; and perhaps justly so, for there is no doubt but t hat the success of the enclosed type of engines may be largely attributable to their being proof against the "tinkerer." But the man with the wrench way work damage in order places as well. In a paper read at the recent meeting of the American Society of Mechanical Engineers, Mr. A. Bement, for example, directed attention to the fact that with the prevailing practice and methods of erecting machinery in final place there is ample opportunity for damage from excessive tightening the nuts and screws on the part of erecting crews, leading to straining of parts beyond there clastic limit. There appears to be no rule in general use for the guidance of the men who perform the work of machinery erection, and it seems usually to be their desire to make things as tight as possible. The natural result is that elastic limits are often exceeded or that breakages even may occur. As an illustration of this Mr. Bement showed a diagram of one end of a vertical Corliss engine cylinder in which the nuts of the studs holding the head to the flangs were screwed up so tight that it resulted in over-strain finding relief in a crack, which developed in the wall of the cylinder just under the flange. A tongue on the head fitted into a groove in the face of the cylinder flange; packing for making the joint was compressed in the groove by the pressure exerted by the tongue; when the packing was fully com-

pressed, further strain owing to over-tightening the bolts resulted in the fracture which manifested itself some weeks after the joint had been made up. The crack extended part way around the cylinder but did not result in entire rupture. It appears that when sufficient relief had been secured the crack ceased to extend, notwithstanding the presence of the steam pressure. This case is probably fairly illustrative of many others of which nothing is heard.

Liquid Air Again

At the St. Louis exposition there will be a demonstration of the powers of "liquid air." This will, no doubt be interesting to a great number of people—especially to those who are holding stock certificates in the now extinct Tripler Company. So many claims have been made for liquid air that the general public have been led to believe that it was the next thing to perpetual motion; Dr. Carl Von Linde gives a very interesting analysis of the fluid which very ably illustrates all phases of the subject.

One of the claims made for liquid air was that it would be "the cold-producing medium of the future." Not only would the working of our modern refrigerating and freezing stores be accomplished by means of liquid air, but everybody—the manufacturer in his workshop and alike the agriculturist on his farm—might, at trifling cost, procure a cool and pure atmosphere for himself. Considering that liquified air, vaporizing at atmosphere pressure, possesses a temperature of 191 deg. C., it is hardly a matter for surprise that, with such an energetic cooling medium in view, the problem of applying liquid air for refrigerative purposes is raised again and again.

In the consideration of the merits of any particular source of cold, two points are essential—first, the quantity of cold produced, *i.e.* the number of heat units eliminated per unit of time; and second, the intensity of the cold, *i.e.* the temperature at which heat is removed.

The most important physical law relating to the production of cold is well known as determining that the expenditure of energy necessary for a certain amount of cold increases in direct ratio with the difference between the lower temperature (in the refrigerator) at which the heat is taken away and the upper temperature(in the condenser or cooler) at which heat is transferred to the cooling water or to the atmosphere. Now, if the refrigerative purposes be the production or the maintenance of a temperature only a few degrees below the freezing point of water, then, according to the law referred to, it must be exceedingly irrational to employ liquid air, seeing that for its attainment we are compelled to descend to 191 deg. C. (312 deg. F.)

Supposing that anyone had to provide a well for obtaininging surface-water from a depth of ten feet, it would be insane to sink a shaft down to three hundred feet, to let the water run from its surface-level down this pit, and then to raise it to a height of three hundred feet. But this exactly corresponds to the idea of persons recommending the use of liquid air as a substitute for all the refrigerating machines of to-day. If we were to work our ice factories, our cooling and freezing stores, and our other cooling plants by liquid air, the requisite expenditure would be from thirty to fifty times greater than that of our modern refrigerating installations.

The Mysteries of Radium

If all that has been said and suggested about that latest puzzle in physics and chemistry—radium—is to be credited, it is superior to the X-rays in medicine, whether as an agent of successful diagnosis, or as an eradicator of malignant fungoid growths. As an illuminant, it is asserted that a very small portion enclosed in a lead box an inch thick, brought near a person in a dark room, produces the same impression as a flash of light upon the retina, even with the eyelids closed, a sensation that is also experienced by the blind.

The heat furnished by the new substance is both intense and lasting, and its stored energy is amazing. Its possibilities as a destructive agent in war have also been considered by German scientists, the claim having been put forth that its power is capable of being projected like the rays of the searchlight, over long distances with destructive effect.

Granting the signal potentialities of light, heat, power, cure and destruction claimed for radium, science must yet solve two practical problems before it can be made to render other artificial light, or coal and the ordinary known sources of heat and power superfluous. The first is that of a sufficient supply, and the second that of a practical means of utilization that will be both safe and certain.

An element so powerful can be confined in few natural subtances, except in the most infinitesimal quantities. The present workable source of supply is said to be pitchblende, which does not contain more than 1–10,000 per cent. of radium for which French and German manufacturers have been able to command $75,000 per ounce. While radium is a substance of which a little may be made to go a good way, the little is so costly at present that common mortals must be content to use something cheaper.

The second unsolved difficulty is that of harnessing the new power so that it can be safely driven. A substance that will produce a light so powerful that even the blind are conscious of its presence, accompanied by a degree of heat that melts everything before it, is liable to burn the fingers of its manipulators unless, as in the case of electricity, they can invent gloves that insulates them against its force. For these reasons the practical value of radium to humanity is still purely problematical. In the face of the marvelous scientific developments of the last century, however, it would be rash to assume that it may not yet become some time more than a scientific curiosity.

Compressed Air for Various Uses in Various Places

The use of compressed air for power purposes and as a means for the transmission of power is much older than is usually conceded. It was used by Smeaton in 1786, by Medhurst in 1810, by Rennie in 1812, by Vallance in 1818, at the Triger mines of Challones in 1845, by Cubitt in sinking the piers of the Rochester bridge in 1851. Brunel also made a similar use of it at Saltash in 1854. It was also used by Brunel on the Thames Tunnel, by Barlow on the Thames Subway, and in the shaft of the Marie Colliery in 1856.

Air has been transmitted for considerable distances and under a great range of pressures. At the Mont Cenis Tunnel air was transmitted to the boring machinery 20,000 feet under a pressure of 105 pounds per square inch. In the installation at Paris, in 1881, by M. Popp, the length of the pipes slightly exceeded twenty-four miles, and the main is a steel pipe 20 inches in diameter, and the air, maintained at ninety pounds pressure, transmits 6,000 horse power.

At Offenbach, near Frankfort-on-the-Main, air is distributed through 25,000 feet of cast iron pipe under ninety pounds pressure. At the Portsmouth Dock Yards, England, air is transmitted through 14,000 feet of pipe, varying from three to twelve inches diameter, under sixty pounds pressure.

There is also a large compressed-air plant at the Terni Steel Works in Central Italy. In this plant, 1,200,000 cubic feet of air per day, under seventy-five pounds pressure, are used.

In this country 2,500,000 cubic feet of air per day, at sixty pounds pressure, delivering 1700 horse-power, are used at the Chapin mines in Michigan. The mains in this plant are 24-inch wrought iron pipes, one-quarter inch thick. Very successful compressed-air tramways have been operated for a number of years at Berne, Switzerland, and at Nantes, France. Mekarski used compressed air for driving tramway cars in 1877.

In all of the above named uses of compressed air, the compression was produced by steam-actuated mechanical compressors. The older ones were all simple compressors, Mekarski being the first to use compound compressors, and he was followed in this line by Northcote in 1878.

The adaptability of compressed air for various uses is very great. While electricity supplies power and light very directly, it cannot be used for heating except at a prohibitive cost. Gas is used very directly to supply heat, power and light, but is expensive for heating and power at the prices generally charged. City water pressure can be used to supply power and indirectly light, by the use of a water motor driving a dynamo, but is too expensive for most purposes. Steam supplies heat and motive power almost directly, and indirectly light through a dynamo. It is, however, more expensive than compressed air, and involves more risk and attention. Compressed air can be used directly as a source of motive power, ventilation and refrigeration; also in the operation of elevators.

We have already mentioned its use in connection with power hammers, cranes and motors. For drying purposes it is even more efficient than heat. Compressed air is also largely susceptible to double uses. For instance, after it has been used cold, or without pre-heating expensively in a motor to produce power, the exhaust furnishes an efficient and cheap method of producing refrigeration. When pre-heated and then used through a motor the exhaust is still hot enough to contribute considerably to the heating of a building.

In the transmission of compressed air over long distances the loss of pressure due to friction in pipes of proper sizes, and the loss due to leakage in properly constructed pipes and joints, are very small. Velocities of from thirty to fifty feet per second are allowable. When an air distribution system is introduced into a thickly settled community, the safety from the air main is much greater than from a steam main or a water main under pressure, and a leakage or even the bursting of such a pipe is attended with very much less damage.

Another great advantage in such a case is that power users require no new plant, and need incur no outlay for motors. Their present steam engines, with little or no alteration, are admirably adapted for serving as air motors.

Tests of small motors of from one to two horse-power using air at the ordinary atmospheric temperature and at 735 pounds per square inch absolute, exhausting from 33 degrees to 54 degrees, required a consumption of 12,000 cubic feet of air per brake horse-power per hour. At the Berne Tramway the air is compressed to 450 pounds per square inch. On the average the cars used about 35 pounds of air per car-mile. This, however, was used in connection with hot water. In small motors of from one to two-horse power, with the air pre-heated to a temperature of about 158 degrees and exhausting at about the freezing point, or 32 degrees, 850 cubic feet of air per brake horse-power per hour were used.

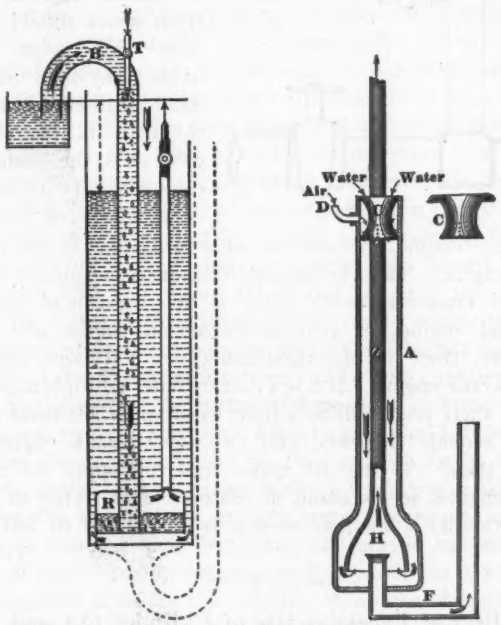
In some very carefully conducted trials made by Professor Riedler, using an 80 horse-power engine which was actually giving 72 indicated horse-power, using air at 80 pounds pressure, heated to 320 degrees, with cylinders jacketed with hot air and exhausting at about 95 degrees, about 425 cubic feet of air per brake horse power per hour were used. This showed an efficiency of about 92 per cent.

Practically, all that has been said above refers to air compressed by the old methods of mechanical compression. We now come to the subject of air being compressed directly by falling water or under pressure. Air compressed by the ordinary methods of mechanical compression contains at least the same amount of moisture as the surrounding atmosphere from which it was compressed; and, in parting with the heat necessarily contributed to the air by the mechanical compression, it is inclined to absorb more moisture. There is incidentally a considerable loss of energy in parting with this heat. Air compressed directly by falling water is kept at the same temperature as this water. It is compressed isothermally, and the consequent expansion, when used in motors, produces an almost truly adiabatic expansion line. Tests, however, have shown that air compressed in this manner contains only one-sixth of the moisture originally in the surrounding atmosphere from which it is compressed. This is probably because the moisture in the bubble of air is pressed or squeezed out of its surface and then absorbed by the surrounding water. Incidentally there is no loss of power in parting with any heat, and there is a practical result which is of more importance—the hydraulically compressed air can be expanded down to a temperature much below the freezing point, while atmospheric air, with the usual amount of moisture, mechanically compressed, cannot be used at all, owing

to the freezing up of the exhaust passages of the motor in which the attempt to use it is being made.

During some tests made at Magog in September, 1899, owing to the conditions under which these tests were made, the change in the humidity in the air was not so great as above stated. The moisture in the external air showed 90 per cent of saturation, and, after compression, 29 per cent., or a little more than one-quarter. In the Magog tests, using an old 75-horse power Corliss engine, with air at 53½ pounds gauge pressure, with cold air direct from the compressor at from 66 degrees to 73 degrees, and exhausting down to the extremely low point of 42 degrees below zero, 850 cubic feet of air per brake horse power per hour were used; and with the air preheated to from 205 degrees to 295 degrees Farenheit, and exhausting at from 67 degrees to 68 degrees, 620 cubic feet of air per brake horse power power per hour were used.

Probably one of the oldest applications of the use of water power to the wants of man was a form of hydraulic air compressor which operated as an entrainment apparatus. This



was the well known water bellows or trompe of the Catalan forges.

This apparatus, briefly described, consisted of a bamboo pole, disposed at a slight inclination from the perpendicular, into the upper end of which a stream of water was led, entraining air with it in its downward passage. The lower end of this bamboo pole was introduced into a bag made of the skin of some animal, the air being allowed to escape from the water into the upper part of the bag, whence it was led by pipes or tuyeres to the forge, the water being allowed to escape from the lower edge of the bag. From this original device a great many improvements have been worked out, and besides this a number of other forms of hydraulic air compressors, or of compressors using other liquids for compressing air or other gases, have been designed.

Siemens invented an apparatus on the principle of the steam injector, but the use of this was confined principally to the production of a vacuum. It is used to operate the pneumatic dispatch tubes in London. It has also been used for blast purposes in Siemen's furnaces and in sugar works.

But all of the apparatus just described did not really employ the same methods as those used in the old trompe. One of the first inventions carrying out this idea was made by Mr. J. P. Frizell, of Boston, Mass. His invention made use of an inverted siphon having a considerable horizontal run between the two legs. A stream of water was led into the upper end of the longer leg and at the top of the horizontal run between the two legs of the siphon was provided an enlarged chamber in which the air separated from the water. The water was then led off from the lower part of this air chamber and passed off through the short leg of the siphon, the pressure of the air accumulated in the air chamber being therefore due to the height of water maintained in the shorter leg of the siphon. This application of carrying upward the water, after the air was separated from it, so as to produce a considerable pressure upon the air, seems to have been original with Mr. Frizell, and in this feature his device differs from the old trompe.

The working head varied from 2.54 feet to 5.02 feet and the efficiency from 40.4 per cent. to 50.7 per cent., the quantity of water in these cases varying from 5.92 to 11.89 cubic feet per second.

From his experiments Mr. Frizell estimates that with a shaft 10 feet in diameter, a depth of 120 feet and a fall of 15 feet the efficiency would be 76 per cent., and that with a head of 30 feet and a fall of 230 feet the efficiency would be 81 per cent.

Another device, Fig. 1, differing somewhat from that of Mr. Frizell, was invented by A. Baloche and A. Krahmass, in 1885, and consisted of a siphon B carrying water from an upper to a lower reservoir, the lower end of the siphon being projected through an inverted vessel R placed nearly at the bottom of the second reservoir. Just beyond the bend of the siphon and the line with the vertical axis of its longer leg, an air pipe T projecting into the descending leg of the siphon, thus entraining the air with the descending column, which carried it down into the inverted chamber R, from which the air escaped at the top, while the water passed out from the bottom into the lower reservoir. This apparatus produced pressure on the air in the top of the inverted chamber, due to the height of the water column upon it.

Another device, Fig. 2, patented by Thomas Arthur, in 1888, differs from the last in having a stream of water led directly into the top of the vertical pipe A. Inserted into the mouth of this pipe was a double cylindrical cone C forming an annular air passage between it and the walls of pipe A.

Owing to the increase in the velocity of the water in passing through the narrow throat of the double cone, air is inhaled through the pipe D through the annular space mentioned and through perforations in the lower cone, and is entrained with the falling water.

Through the down flow pipe A rises a vertical delivery pipe Z for the compressed air, having its lower end enlarged and open at the bottom. Projecting upward into this enlarged air-delivery pipe was a water-escape pipe F through which the water passed after having parted with the air. This escape pipe was in the form of an inverted siphon and animatined on the air in the delivery pipe Z a pressure due to the elevation of the water at its discharge point above the air line in the large end of the delivery pipe.

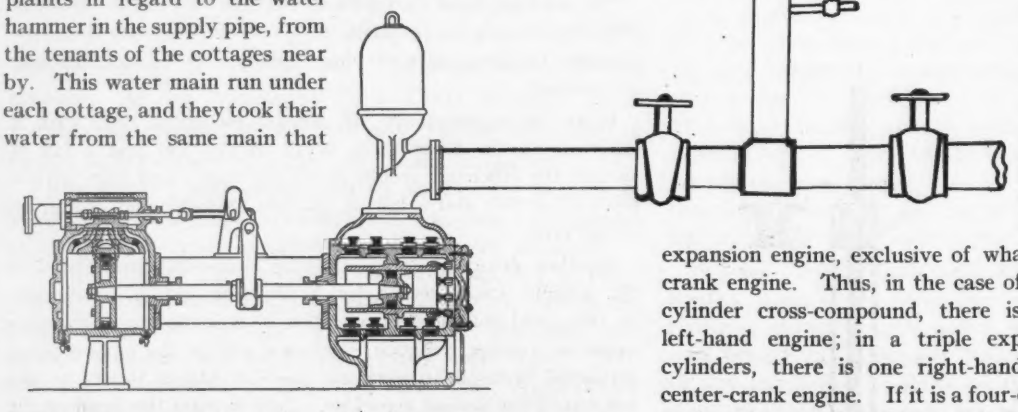
LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

Water Hammer

Editor THE PRACTICAL ENGINEER:

A few years ago I took charge of a small electric light plant which consisted of two 100-horse power engines, two boiler feed pumps and three return tubular boilers. I was informed by the superintendent that they had received several complaints in regard to the water hammer in the supply pipe, from the tenants of the cottages near by. This water main run under each cottage, and they took their water from the same main that



supplied the station. He also informed me that if I could make any change to remedy this trouble it would be very much appreciated. The suction was a 2½ inch pipe, this I cut and bushed to take a 5-inch tee; into this 5-inch tee I screwed a 5-inch pipe six feet long and the upper end of same capped with an air valve as shown in the sketch. This did the trick, and thereafter if the knock opened, valve AA was closed and air valves opened at the side and top to let out the water in the top of the pipe and let in a new supply of air. The superintendent was well pleased with the kink and I was well paid for my work.

W. A. DOW,
Cambridge, Mass.

The Right-Hand Engine Again

It seems that the question of whether an engine is right-hand or left-hand will not down. I confess that I have considerably enjoyed the discussion which the point has brought out and I would like to put in my oar concerning it.

My first conception, and indeed my only conception, of a right-hand or left-hand engine is precisely that given in the June issue of this paper. I notice, however, that Mr. Hardenberg takes exception to that method of distinguishing between the two because he has an engine to which the rule will not apply. Now, I do not have a clear idea as to what the "Metropolitan" engine looks like. For how the flywheel can be on the opposite side of the connecting-rod from the crank without there being continuation of the shaft connected to the first crank by a second, is beyond me. And if this is the construction of the "self-contained" engine, it is nothing more or less than a center-crank engine. However, if there is only *one* crank, and it is opposite the flywheel, then, truly, Mr. Hardenberg has a freak engine. I would be glad to see a catalogue describing the engine in question and showing illustrations of it. I have endeavored to find it advertised in one or more of the mechanical journals, but have been unsuccessful.

In the case of the center-crank engine I do not think that the rule given should be expected to apply at all. In such an instance, there is a crank disk on either side of the connecting-rod, these two disks being joined by a common crankpin. Consequently there are two cranks, one at either side, and the engine cannot be classed either as a right-hand or as a left-hand engine. I do not agree with the writer of the editorial in last month's issue, in which he states that the governor wheel should determine this point. The terms right-hand and left-hand are intended to apply to horizontal simple engines or to the component elements of a duplex, compound, or multiple expansion engine, exclusive of what is known as the center-crank engine. Thus, in the case of a duplex engine or a two-cylinder cross-compound, there is one right-hand and one left-hand engine; in a triple expansion engine with three cylinders, there is one right-hand, one left-hand, and one center-crank engine. If it is a four-cylinder multiple expansion engine, there must still be a right-hand and a left-hand engine as the outside elements, and two center-crank engines between them. Trying to make this rule apply to center-crank engines seems about as reasonable as trying to determine whether a monkey-wrench is right-hand or left-hand.

X. N. TRICK.

The Effect of Excessive Use of Cylinder Oil, and What Happened to a Spiteful Engineer

Editor PRACTICAL ENGINEER:

In the early spring of '92 I had an experience with an engine and an engineer that I will not soon forget. It was nothing very serious, but at the same time worthy of mention. I was employed as a machinest in a local engine shop, in Dunkirk, N. J., where logging engines were made and repaired. The company built a small logging engine of the geared type for a large lumber company in West Virginia. In due time the machine was tested, put on a car and shipped to its destination, where from the start the Lumber Company were very well pleased with the performance of the engine, and were about to order another when the subject of my experience took place. The shop foreman received a telegram that the engine would not work after a thorough trial by some of their best engineers. The message came at night, and the next day I was sent to look over the machine and repair it if possible. In due time I arrived at the little station and was driven several miles into the interior to where the engine was, for it was at least

five miles from the mill, and apparently impossible to get it back. My first move on reaching the machine was to closely question the engineer as to what he thought was wrong. I gained very little from him for he seemed sullen and in no way pleased with my presence on the scene. So to make matters as well as possible I examined the engine thoroughly, looking over valve gear and in fact everything that would be liable to get out of order easily. I found everything apparently O. K., so after seeing that the boiler contained enough water, I fired up, and raised the steam pressure to 100 lbs.; I drained the steam line, and opened the cylinder cocks, then I gradually opened the throttle, and as I did so the little engine made two or three revolutions and stopped, with a choking action. I shut the throttle, and proceeded at once to open the front end of the boiler to examine the exhaust nozzle, which I found very nearly stopped up by a formation of corrosion, caused by the excessive use of the cylinder oil of the West Virginia grade, common to that locality. Just as I discovered the fault with the nozzle the proprietor came along and inquired what was at fault. I explained the case to him while I was cleaning out the nozzle, and he sorely reprimanded the engineer for not looking into the matter more thoroughly. About the time I had the nozzle ready for use again it was noon hour, so we went to dinner, resolving to give the machine a good test after dinner. On returning from dinner I closed up the front, shook down the fire and tried to make another start, but this time the engine refused to move at all. But after a careful examination I found that the couplings between the two engines had been shifted so that the cranks were opposite, instead of being quartered, and that they were both placed on their centers. The bolts were taken out to shift the coupling, in order to change the positions of the cranks so that the engine would not start at the opening of the throttle, but fortunately I noticed the change and just as I called the engineer's attention to the matter the manager stepped up to know if everything was ready to start, and when he saw what had been done, he told the engineer to get his time at once for he had been left in charge of the engine while I was away. Well, after setting the cranks back in their correct positions, and oiling up and draining cylinders, etc., the engine started off and ran all right, and is running to-day, as far as I know, but the engineer is not in that locality from what I hear, and on my return home I carried an order for engine No. 2.

Boiler Cleaning and Scale Trouble

Editor PRACTICAL ENGINEER:—

A great many engineers have expressed their opinion as to the proper place to introduce the feed into boilers, especially those of the return tubular type, and perhaps it will be impossible to say anything new along this line; but a bit of the writer's experience may help some one to better the condition of his boiler or boilers.

Some time ago the writer took charge of an electric railway power house, where return tubular boilers were used to generate the steam. Duplex feed pumps were used, the water being forced through an exhaust feed-water heater into the boilers through the blow-off. On examination the boilers were found to be badly scaled, particularly the back heads about half way up, and the three lower rows of tubes for half their length.

Inquiry as to how the boilers had been treated for the scale revealed the fact that they had been treated regularly each day with kerosene and each boiler cleaned once each month. I readily concluded that oil was not the proper thing for this case and decided to try something else as soon as possible. We first changed the feed by allowing the pipe to enter the boiler at the top about two and one-half feet from the front head down to within six inches of the top row of tubes, thence toward the back to within three feet of the back head; capped the pipe and had enough 3-16 inch holes drilled in each side of the pipe to equal the area of the pipe. While this arrangement works well I have found by later trial a cross pipe placed at the end of the long pipe, and holes drilled in it instead of the long piece, admits of the temperature of the water being raised much higher than in the former arrangement.

After this arrangement was completed I sent some of the scale to a well known firm, had it analyzed, some compound made to suit the case, and as soon as it arrived commenced the use of it according to directions. The boilers were cleaned each month as usual and before long the scale had disappeared from the back head, lower sheet and tubes and we had a clean boiler. Of course some scale would continue to form in the boiler, but it is mostly on the top of the top row of tubes where it is readily removed.

Many engineers recommend feeding in the blow-off, but I have failed to find as yet that place where it can be recommended in preference to the top. Some one says passing the feed-water through the blow-off keeps the latter free from scale; true, so will opening the blow-off cock once each day or oftener if the water is very bad. Another say the blow-off pipe will not burn out so soon if the blow-off feed is used; granted, but the damage to the bottom of the boiler and tube ends caused by contraction and expansion, especially when the feed is intermittent, is of much more consequence than the burning out of the blow-off pipe.

A boiler came to my notice at one time with which there had always been trouble because of the girth seams leaking, also the tube ends of the lower row of tubes at the back. Any amount of calking was of no avail, until one day some one recommended the feed to be changed from the blow-off to the top; this was done and there has since been no more trouble with leaky seams or tube ends.

It does seem that some engineers and some manufacturers of boilers have the idea that if you stick the feed pipe in any old place in a return tubular boiler, it is all right so long as the water gets there. It is my belief that if the same care were exercised in the manufacture of return tubular boilers, and those similar designs as with the water-tube boiler, there would be fewer accidents laid at their door.

Lloyd, N. Y. A. K. VRADENBURGH.

The Lunkenheimer Outing

The Lunkenheimer Company, of Cincinnati, gave their annual outing at Woodsdale Island Park, Saturday, July 18th. Seven hundred employees and their families participated this year, in all about two thousand people, including children. Everything was free, including transportation, refreshments, music and dancing, the entire expense of the outing being paid by the company.

Woodsdale Island Park is about thirty-one miles from Cincinnati, on the C. H. & D. railroad, and it required two sections of ten coaches each to carry the passengers.

The Details of Steam Making

The cost of generating steam in a boiler is made up of several factors, each of which involves and is governed by mere details. the location of the boiler has primarily a very important bearing on economical results, and too little attention is paid to it. If it is necessary that the boiler be placed in a cellar or dark room, its surroundings at least should be kept just as clean and bright as possible. The tendency is unfortunately to allow the walls, windows and surroundings to remain dirty and dusty without any more cleaning than is absolutely unavoidable, and the boiler and everything connected with it are sure to follow into that same uncared-for state of inefficiency. Relatively as much exertion should be spent in "shining up" the boiler fittings and cleaning the boiler room as is spent on the engine and engine room. A clean, brightly-painted room lends an incentive to keeping fittings clean and to giving the boiler proper care; furthermore, plenty of light makes it much easier to inspect and clean the boiler and flues thoroughly. Even if a boiler room is necessarily small and dark there is no reason why gauges, valves, injectors, and all other fittings should not be kept polished bright and in good working order, and all important parts and fittings adequately illuminated by means of artificial light.

Economy in the production of steam is not necessarily secured by installing a modern plant with high-grade boilers, auxiliaries, etc. It depends as much upon the proper handling and care of the machinery as upon its grade; and perhaps more. The highest possible economy is secured only when the apparatus is operated under the very best conditions. The average steam engine, with its perfection of detail and the careful attendance it usually gets, operates under extremely "favorable conditions," so that it is not uncommon to find an engine developing a horse-power with a consumption of from 10 to 15 lbs. of steam an hour. But the average boiler, with the lack of intelligent care and dark, dirty surroundings which are regrettably common, usually operates under very unfavorable conditions and is undoubtedly the most wasteful portion of the power plant, a result which is altogether unnecessary.

The internal condition of the boiler is probably the most important factor in the steam-making problem; cleanness is nowhere so profitable as inside a steam boiler. Actual tests have shown an evaporation of from 7 to 8 lbs. of water per pound of coal in a thoroughly cleaned boiler, while with one-eighth of an inch of scale the evaporation was reduced in the same boiler to between 4 and 5 pounds of water per pound of the same coal; the cost of steam being nearly doubled by the very small accumulation of scale mentioned. Thus, the the importance of cleaning the boiler thoroughly and often cannot be over-estimated, although much too frequently it is neglected or cared for by the baneful method of "blowing off hot." In blowing off hot, all scale that is not readily washed out by the outflow of water will dry and bake on the heating surface in cakes, which it is difficult to remove when they are once solidified. This pernicious method will also do more harm to the boiler, in the way of straining seams and loosing tubes by the sudden contraction, than would follow from years of service. A boiler should always be allowed to cool down before the blow-off valve is opened. Then when the manholes and hand-holes are opened, it will be found that the sediment on the flues and shell is soft, sludgy and easily washed off with a hose. If the supplementary washing off is neglected, this sludgy sediment settles upon the heating surfaces and is gradually baked hard, after which it can be removed thoroughly only by chipping out with a scale pick.

The formation of this sludge, which subsequently bakes into scale unless washed out, is unavoidable unless pure feed water can be obtained, and this, of course, is rarely possible. If incrustation forms and it is inconvenient to shut the boiler down for cleaning, it may be advisable to have the feed water analyzed by a reliable chemist, and then treat it chemically to remove the impurities revealed by the analysis; or better yet, to use a feed-water purifier of the lime-catching type. Such a purifier will remove practically all solids that are present in feed water by simply heating the water to the temperature at which it precipitates all or most of its solid matter.

For the same reason that renders scale objectionable the impairment of heat-transferring efficiency, the outside of the heating surfaces should receive as much attention as the inner or water side. In practice, the outer surfaces usually receive much more attention than the interior on account of being easier of access, but the cleaning of these surfaces is also too often done indifferently. The soft deposit or coating of soot which forms very rapidly on the fire side of heating surfaces cannot be prevented, but must be cleaned off frequently. The under side of the boiler shell may easily be scraped and then swept off, but it should not be swept only, because sweeping alone may not thoroughly remove the deposit. For the flues a scraper is necessary, even when a "sootsucker" or blower is used, as a steam or air jet rarely if ever thoroughly cleans a flue. If the fuel is such that the soot is at all tarry or sticky, the soot must be scraped out as it can be removed in no other way. The arrangments for cleaning the flues should be made as convenient and complete as possible, in order to facilitate the performance of the work in a careful and thorough manner. In many boiler rooms a folding staging is arranged so as to be easily placed in front of the flue door, and this facilitates thorough and rapid work. Too much attention cannot be paid to this matter of cleaning the boiler inside and out, as this is probably the most important factor in steam production from the viewpoint of economy.

The draught is also an important factor in the cost of steam production. A draught suitable for one coal may not be suitable for another; for instance, a fine coal requires a stronger draught than a coarse coal. For this reason the damper in the chimney flue should be arranged so that it can be adjusted from a point near the furnace doors in order that the fireman may regulate the draught to suit his coal and to meet the demand for steam. By properly checking the draught, much coal may be saved at times that would otherwise be wasted by steam blowing off through the safety valve; moreover, a checked fire may be more quickly "opened out" when steam is needed again than if the fire had been allowed to die down.

For the maintenance of a good draught it is essential that the brick work about a boiler be maintained perfect. Any cracks admitting air through the setting should be stopped, as they tend to cool the boiler and impair the draught. All brick settings are liable to settling as well as disintegration by heat, and cracks should be looked for frequently. It is well to have the masonry refinished if it has settled or cracked. A coat of whitewash applied to the setting will stop up enough imperceptible cracks to more than pay for the expense. Doors

in the setting very frequently give lots of trouble by not closing tightly and thus impairing the draught greatly, but they can easily be made tight by stuffing the edges with sheet asbestos or any other convenient non-combustible material.

All parts of the boiler not covered by brickwork should be carefully covered with a non-conductor of heat. If the top of the boiler is set so that it cannot be covered by strong cement mortar, it should be covered with magnesia, asbestos, or a a cement of some suitable non-conducting material. Exposed steam surfaces may condense from one-third to one-half a pound of steam per square foot per hour or more if exposed to air currents, and thus very materially increase the cost of steam delivered. A good covering 1 inch thick will reduce this condensation loss about 80 per cent. An example of the economy resulting from a covering may be given by considering 100 sq. ft. of exposed steam surface. With condensation at the rate of ½ lb. of steam per square foot per hour, there would be a loss of 50 lbs. of steam per hour, 1200 lbs. per day of twenty-four hours, or 432,000 lbs. per year of 360 days. Assuming that one pound of coal produces 7 lbs. of steam, this would represent a waste of nearly thirty-one tons of coal, or $75 to $90. Eighty per cent of this might be saved with a good covering, so that upon investment of from $15 to $25 for 100 square foot of covering, a saving of from $60 to $70 would be effected in a year. Even if the boiler were fired only 10 hours a day the covering would save its own cost in a year. This argument applies to steampipes, valves and fittings as well as to the boiler top and dome.

Another very important factor is that of the firing. Good economy may be obtained in firing by closely watching the steam and water gauges and the judicious use of the damper and boiler feed, in contrast with the too general method of simply crowding in all the coal possible with the least effort. It has been said that the waste due to improper firing is often greater than any other loss in the operation of a steam plant. If the proper conditions of good draught, an even fire, and systematic even firing be observed, as high economy should result by hand firing as is obtained with mechanical stokers. In marine boiler firing on the Great Lakes the firemen spread their coal evenly over the entire grate at each firing, and they produce steam economically; while firemen on many coastwise steamers on the Atlantic pile up the coal just inside the furnace door, and, as it becomes coked, spread it back over the incandescent fire behind, and obtain fully as high economy as the lake firemen. These methods of firing are equally good, but in all cases the gratebars should be kept entirely covered, and the amount of air required above the grate for complete combustion should be admitted from above instead of from below the grate.

Equally important with the firing is the quality and price of fuel. Of course the selection of the grade of coal to be used will depend upon the coal available, as well as its price. But it is a great mistake to think that coal of a low price will necessarily result in a low cost of steam. A cheap coal may be so utterly poor from shale and dirt as to give extremely poor results. It is advisable to consider the question of freight as a part of the coal cost, especially when the coal is to be used at a considerable distance from the mine. A coal that is worth 60 to 75 cents a ton at the mine may be worth $3 or $4 a ton several hundred miles from the mine, due to the freight charges. Obviously, when the actual cost of the coal is so small a percentage of its market price at the point of consumption it does not pay to buy a cheaper coal, as a coal of slightly higher price at the delivery point might mean a coal of double the steam-producing quality.

The best way to select a coal is to test it, in actual use under the boiler in comparison with other grades. Sufficient coal of the kind to be tested should be obtained and a ten-hour test made with it under the boiler, which will show exactly what the coal is capable of doing under the actual conditions of operation. The carrying out of such a test is comparatively simple if a platform scale is at hand and and it is possible to insert a thermometer into the boiler feed-water pipe. The only measurements neccessary are the number of pounds of water fed to the boiler, the number of pounds of coal burned, the average temperature of the feed water and the average steam pressure in the boiler; from these, providing the test is started and stopped with the boiler under exactly the same conditions as to height of water, steam pressure, etc., the actual number of pounds of water evaporated by a pound of the coal on trial may be calculated. Then a similar test should be made with another coal to be compared, care being taken to maintain the steam pressure and feedwater temperature as nearly as possible the same as they were in the first test. This sort of comparative testing will furnish a clear idea as to the relative merits of two or more kinds of coal, and has been used in some places with great economic advantage. In one instance, a coal that was thought to be the best grade obtainable did not show as high evaporation as cheaper coal with shale in it, and in other instances cheap coals have been proven less economical than higher priced coals.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Editor PRACTICAL ENGINEER:—

Will you answer the following questions: First, is there any power in vacuum? Second, is there any power in a suction further than to remove the air and form a vacuum?

If there is no power in the vacuum why will a compound engine start by merely opening the exhaust valve between the engine and condenser with twenty-eight inches of vacuum, all other communications being closed except the drips between the engine cylinders and the atmosphere?

Why will water flow through a syphon as long as the outlet of same is below the inlet? S. B. ALDRICH.

First. There is a power in vacuum equal to the number of square inches of surface exposed to the atmosphere on one side with a vacuum on the other: For instance, if we have an

engine cylinder and extract all the air from one side of the piston then open a cock admitting air to the other side, we will find that the action of the air will have the same effect as the admission of steam, at fifteen pounds pressure, would have without the vacuum. You can thus readily see why the compound engine, or any other engine, will move by creating a vacuum in the cylinders.

Water flows from a syphon for the same reason that the engine piston moves. It is operated by filling the drop leg, or long end, with water and then letting it empty out with the short end in water; in thus emptying the pipe a vacuum is created into which water is forced by atmospheric pressure on the surface. It is necessary to have the end of the drop leg longer than the suction end because there is a friction in the pipe, which if not overcome by a greater vacuum on one side than the other would fail to raise the water high enough to flow over the highest point. EDITOR.

Editor PRACTICAL ENGINEER:

Can you explain to me how to determine the direction of the magnetic field of a straight current.

E. B. GRUBB.

Place on a table or any convenient means of support, and in such a position that the wire to be experimented on can be moved all around it, a freely supported horizontal test needle You will observe that the needle takes up a position in a line with a magnetic meridian and that of the north pole points towards the north.

Holding a straight copper wire above, below, or in any position near and parallel to the magnetic axis of the needle has no effect whatever on the needle, as no deflection of the needle is observed.

Let this copper wire be a wire connecting the terminals, or any generative source of electricity, with a switch placed in some part of the wire that the current may be thrown on or off at the will of the experimenter. The most convenient switch to use for ordinary experiments is the spring contact, which is so constructed that the button is pressed down, overcoming the resistance of a spring to complete the circuit; when pressure is withdrawn the circuit is broken by means of this spring and action in the battery ceases.

Again, hold this straight copper wire parallel with the magnetic axis of the needle (or fasten by any means of support to better manipulate the switch) and cause a current of electricity to pass over the wire by making connections with the switch. The needle is now disturbed and we notice that it is deflected in our direction and will remain so deflected while we hold the switch in contact. The instant we release the switch (break the circuit) the needle resumes its normal position parallel with the magnetic meridian.

Without changing the position of the wire and opening and closing the switch several times in quick succession we notice the deflection of the needle is always in the same direction. If a battery is used the angle of deflection may decrease perceptibly on account of loss in the cell. If the first position of the wire was above the needle, and it is now placed below, and current sent over the wire, we notice a difference in deflection, so also if we reverse the wire by changing end for end, or, what would be the same, change the terminal connections. It is clearly evident from the experiment that there is a difference in the direction of the magnetic lines of force produced by the current according as the current is flowing in one direction or the other.

We wish now to determine this difference and to know precisely in which direction the magnetic lines of force are moving for a known direction of current.

The following statement will greatly assist in all experiments with suspended magnets, and it is not difficult to understand and remember: If a magnet body free to move in any direction be placed in a magnetic field, it will always move so as to accomodate through itself the greatest number of lines of force of the field, in the same direction as its own external lines.

The deflection of the magnetic needle then is such that the lines of force of the field in which it is placed are flowing through the needle, this being an easier path than through the surrounding air space.

The magnetic lines of force on which (as they are sometimes called) travel at right angles to and around the wire carrying the current. Let us determine from the above data their particular direction.

Place the iron over and parallel to the magnetic needle, with the wire so connected at the battery terminals that the current shall flow from the north toward the south pole; close the circuit and we see the deflection is to the west, or, if you are facing the north-seeking pole the deflection is from you, such being the case we say that the magnetic lines of force are passing through the needle (the needle having accomodated itself to the directions of those lines as deduced from our statement) under the wire in a direction from the south pole to the north pole pass over the wire to the south pole. Placing the wire under the needle, or changing the connections at the terminals, will change the direction of the deflections of the needle.

A rule that can easily be remembered after a few trials is: Place the right hand above the wire, with the palm of the hand towards the wire, and with the fingers pointing in the same direction the current is flowing, extend finger, the thumb will indiate the direction of the north pole of the magnet, which in this case we remember was placed under the wire.

To use this rule correctly the fingers must always point in the direction the current is flowing, and the palm of the right hand must always be on the opposite side of the wire, and not on the same side of the wire as the needle. EDITOR.

Editor of PRACTICAL ENGINEER:

I have had it stated to me that, in the case of a boiler explosion resulting from the admission of cold water into a heated and empty boiler, a gas is formed which caused the explosion. I disputed the idea because I knew of no possible way in which a gas could thus be generated except by the separation of "water," H_2O, into its elements, hydrogen and oxygen. I stated my opinion to the effect that such an explosion was merely the very rapid formation of steam, to such a degree, as overtax the strength of the boiler.

If you could inform me as to the true state of such an explosion I shall be grateful.

Also do you know of any acid or solvent which can be put into a boiler to dissolve or eat up the lime of the water without injuring the boiler? I know of no acid which will act upon lime without at the same time affecting the iron.

C. C. LOYSTER, Hudson, Mich.

The effect of heat applied to water is to vaporize it; now if we take a steam boiler and fill it with water, apply heat in sufficient quantity, we will vaporize the entire contents. It must be understood, however, that during the entire process the water never acquires a heat beyond a certain limit. The limit being regulated by the amount of pressure—at 100 pounds pressure water cannot become hotter than 327° F.

After we have reduced the contents of the boiler to vapor-steam, we can then, however, heat the steam to almost any degree, and it is to this fact that explosions result from low water, and no other. As long as water covers the heating surface of the boiler metal the iron cannot become hotter than the water in direct contact with it. But as soon as the water falls below the line of metal coming in direct contact with the fierce heat of the furnace, the metal will attain—and very rapidly—a red heat which simply softens the iron, killing its strength, thus permitting the steam pressure to force it apart with the usual violent results.

We have, however, one other cause of erruption from low water, and that is the admission of cold water upon the overheated plates. We will presume that the water is low and that the plates are pretty hot, but not hot enough to be strained apart by the internal pressure. Now let us admit water on the sheets, and wherever the water strikes there is an instant contraction of the metal which causes a separation or crack in the sheet—along the line between the hot and the cooler iron. It is due to either of the above causes that explosions occur from low water and no other.

The stories and theories suggesting explosive gases being generated within the boilers and then exploding are simply hallucinations of the mind.

Referring to the question of reducing your lime scale we would advise you to correspond with some reputable boiler chemical house, who will be glad to analyze the water and supply the proper remedy free from injurious elements to the iron. You will find a number of such in the advertising columns of the PRACTICAL ENGINEER.—[EDITOR.]

Editor PRACTICAL ENGINEER:

Will you publish in your columns a comprehensive description of determining the vacuum in the section pipe.

CHAS. S. EDISON.

Take a pump located thirty-four feet above the surface of the water in the well and assume that it produces a perfect vacuum. While it is true that no pump is capable of producing a perfect vacuum, it may be assumed for the purposes of this discussion that the action of the pump is perfect and that a vacuum corresponding to thirty inches of mercury is formed. When the pump is started, water will rise in the pipe, owing to the pressure of the atmosphere on the surface of the water in the well. The pressure or weight of the atmosphere varies with the altitude, the humidity of the air, and general barometric conditions. Thirty-four feet is the height water will rise in a perfect vacuum at sea level with the barometer indicating thirty inches of mercury. At thirty-four feet water will cease to rise because the weight of the water in the pipe per unit of area just counterbalances the weight of the atmosphere on a unit of area of the surface of the water in the well. Obviously, if the vacuum is perfect, the gauge at A will show thirty inches of vacuum.

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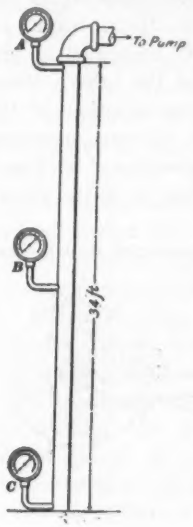

In like manner it can be shown that the vacuum at any point varies directly as the height above the water in the well, since the counterbalancing effect of the water above the chosen point varies directly as the distance from the point taken to the top of the water in the pipe.

Editor PRACTICAL ENGINEER:

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1. How would you proceed to fasten the rope to the drum of a coal-hoisting engine?

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E. HUMMEL, JR.

1. You will usually find a hole drilled in the drum about the size of the rope used; to fasten the rope slip it through the hole and screw a clamp upon it—there are special clamps made for the purpose. The other questions asked will be found answered in detail in the following article.—[EDITOR.]

engine cylinder and extract all the air from one side of the piston then open a cock admitting air to the other side, we will find that the action of the air will have the same effect as the admission of steam, at fifteen pounds pressure, would have without the vacuum. You can thus readily see why the compound engine, or any other engine, will move by creating a vacuum in the cylinders.

Water flows from a syphon for the same reason that the engine piston moves. It is operated by filling the drop leg, or long end, with water and then letting it empty out with the short end in water; in thus emptying the pipe a vacuum is created into which water is forced by atmospheric pressure on the surface. It is necessary to have the end of the drop leg longer than the suction end because there is a friction in the pipe, which if not overcome by a greater vacuum on one side than the other would fail to raise the water high enough to flow over the highest point. EDITOR.

Editor PRACTICAL ENGINEER:

Can you explain to me how to determine the direction of the magnetic field of a straight current.

E. B. GRUBB.

Place on a table or any convenient means of support, and in such a position that the wire to be experimented on can be moved all around it, a freely supported horizontal test needle You will observe that the needle takes up a position in a line with a magnetic meridian and that of the north pole points towards the north.

Holding a straight copper wire above, below, or in any position near and parallel to the magnetic axis of the needle has no effect whatever on the needle, as no deflection of the needle is observed.

Let this copper wire be a wire connecting the terminals, or any generative source of electricity, with a switch placed in some part of the wire that the current may be thrown on or off at the will of the experimenter. The most convenient switch to use for ordinary experiments is the spring contact, which is so constructed that the button is pressed down, overcoming the resistance of a spring to complete the circuit; when pressure is withdrawn the circuit is broken by means of this spring and action in the battery ceases.

Again, hold this straight copper wire parallel with the magnetic axis of the needle (or fasten by any means of support to better manipulate the switch) and cause a current of electricity to pass over the wire by making connections with the switch. The needle is now disturbed and we notice that it is deflected in our direction and will remain so deflected while we hold the switch in contact. The instant we release the switch (break the circuit) the needle resumes its normal position parallel with the magnetic meridian.

Without changing the position of the wire and opening and closing the switch several times in quick succession we notice the deflection of the needle is always in the same direction. If a battery is used the angle of deflection may decrease perceptibly on account of loss in the cell. If the first position of the wire was above the needle, and it is now placed below, and current sent over the wire, we notice a difference in deflection, so also if we reverse the wire by changing end for end, or, what would be the same, change the terminal connections. It is clearly evident from the experiment that there is a difference in the direction of the magnetic lines of force produced by the current according as the current is flowing in one direction or the other.

We wish now to determine this difference and to know precisely in which direction the magnetic lines of force are moving for a known direction of current.

The following statement will greatly assist in all experiments with suspended magnets, and it is not difficult to understand and remember: If a magnet body free to move in any direction be placed in a magnetic field, it will always move so as to accomodate through itself the greatest number of lines of force of the field, in the same direction as its own external lines.

The deflection of the magnetic needle then is such that the lines of force of the field in which it is placed are flowing through the needle, this being an easier path than through the surrounding air space.

The magnetic lines of force on which (as they are sometimes called) travel at right angles to and around the wire carrying the current. Let us determine from the above data their particular direction.

Place the iron over and parallel to the magnetic needle, with the wire so connected at the battery terminals that the current shall flow from the north toward the south pole; close the circuit and we see the deflection is to the west, or, if you are facing the north-seeking pole the deflection is from you, such being the case we say that the magnetic lines of force are passing through the needle (the needle having accomodated itself to the directions of those lines as deduced from our statement) under the wire in a direction from the south pole to the north pole pass over the wire to the south pole. Placing the wire under the needle, or changing the connections at the terminals, will change the direction of the deflections of the needle.

A rule that can easily be remembered after a few trials is: Place the right hand above the wire, with the palm of the hand towards the wire, and with the fingers pointing in the same direction the current is flowing, extend finger, the thumb will indiate the direction of the north pole of the magnet, which in this case we remember was placed under the wire.

To use this rule correctly the fingers must always point in the direction the current is flowing, and the palm of the right hand must always be on the opposite side of the wire, and not on the same side of the wire as the needle. EDITOR.

Editor of PRACTICAL ENGINEER:

I have had it stated to me that, in the case of a boiler explosion resulting from the admission of cold water into a heated and empty boiler, a gas is formed which caused the explosion. I disputed the idea because I knew of no possible way in which a gas could thus be generated except by the separation of "water," H_2O, into its elements, hydrogen and oxygen. I stated my opinion to the effect that such an explosion was merely the very rapid formation of steam, to such a degree, as overtax the strength of the boiler.

If you could inform me as to the true state of such an explosion I shall be grateful.

Also do you know of any acid or solvent which can be put into a boiler to dissolve or eat up the lime of the water without injuring the boiler? I know of no acid which will act upon lime without at the same time affecting the iron.

C. C. LOYSTER, Hudson, Mich.

The effect of heat applied to water is to vaporize it; now if we take a steam boiler and fill it with water, apply heat in sufficient quantity, we will vaporize the entire contents. It must be understood, however, that during the entire process the water never acquires a heat beyond a certain limit. The limit being regulated by the amount of pressure—at 100 pounds pressure water cannot become hotter than 327° F.

After we have reduced the contents of the boiler to vapor-steam, we can then, however, heat the steam to almost any degree, and it is to this fact that explosions result from low water, and no other. As long as water covers the heating surface of the boiler metal the iron cannot become hotter than the water in direct contact with it. But as soon as the water falls below the line of metal coming in direct contact with the fierce heat of the furnace, the metal will attain—and very rapidly—a red heat which simply softens the iron, killing its strength, thus permitting the steam pressure to force it apart with the usual violent results.

We have, however, one other cause of erruption from low water, and that is the admission of cold water upon the overheated plates. We will presume that the water is low and that the plates are pretty hot, but not hot enough to be strained apart by the internal pressure. Now let us admit water on the sheets, and wherever the water strikes there is an instant contraction of the metal which causes a separation or crack in the sheet—along the line between the hot and the cooler iron. It is due to either of the above causes that explosions occur from low water and no other.

The stories and theories suggesting explosive gases being generated within the boilers and then exploding are simply hallucinations of the mind.

Referring to the question of reducing your lime scale we would advise you to correspond with some reputable boiler chemical house, who will be glad to analyze the water and supply the proper remedy free from injurious elements to the iron. You will find a number of such in the advertising columns of the PRACTICAL ENGINEER.—[EDITOR.]

Editor PRACTICAL ENGINEER:

Will you publish in your columns a comprehensive description of determining the vacuum in the section pipe.

CHAS. S. EDISON.

Take a pump located thirty-four feet above the surface of the water in the well and assume that it produces a perfect vacuum. While it is true that no pump is capable of producing a perfect vacuum, it may be assumed for the purposes of this discussion that the action of the pump is perfect and that a vacuum corresponding to thirty inches of mercury is formed. When the pump is started, water will rise in the pipe, owing to the pressure of the atmosphere on the surface of the water in the well. The pressure or weight of the atmosphere varies with the altitude, the humidity of the air, and general barometric conditions. Thirty-four feet is the height water will rise in a perfect vacuum at sea level with the barometer indicating thirty inches of mercury. At thirty-four feet water will cease to rise because the weight of the water in the pipe per unit of area just counterbalances the weight of the atmosphere on a unit of area of the surface of the water in the well. Obviously, if the vacuum is perfect, the gauge at A will show thirty inches of vacuum.

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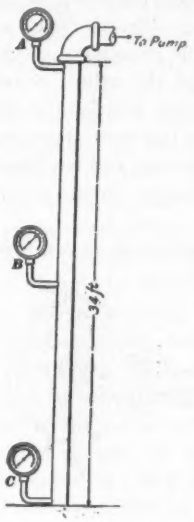

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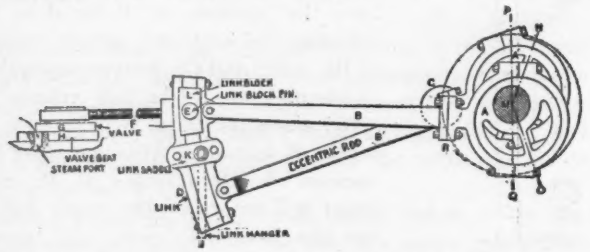
Setting a Plain Slide Valve With Link Motion

The setting of a slide valve operated by a link motion does not differ materially in principle from the method pursued when setting the ordinary slide valve driven by one eccentric. A link motion may be considered as a means of driving a valve by two independent eccentrics, either of which controls the functions of the valve wholly or in part, according to the position of the link. Thus when the link is in either extreme position, the eccentric driving that end of the link-in line with the link-block pin may be considered as being entirely in control of the valve action, and, *vice versa*, when the link occupies the other extreme position of its throw, as actuated by the reverse lever, the other eccentric becomes possessed of the controlling function. Practically, however, the operation of the link motion is very complicated and the movement of one eccentric materially modifies the action of the other. Since the interfering action is least at the extreme positions of the link and greatest in mid-gear the plan is followed of setting the valve with the link in full gear both forward and backward motion, and, as before stated, the procedure is on the theory of independent action of the eccentrics.

In the accompanying diagram, a link motion is shown driving a plain slide valve without the intervention of a rocker. Each eccentric is set with reference to the crank-pin, the same as it would be with a simple slide-valve engine. The eccentric A is set on the shaft with the same angular advance, Q M O, as would be required for an ordinary engine to run in the direction indicated by the arrow. Now, since the crank pin is at C, if it were necessary to reverse the simple engine with one eccentric, it would be necessary to change the position of the eccentric so that instead of being ahead of the bottom quarter line Q M, it would be ahead of the top quarter line P M by an amount of angular advance made necessary by the lap and lead of the valve. Therefore, the eccentric would come in the position of the eccentric A or with its centre line coinciding with M N, giving it the angular advance P M N. Now it should be clear that if an engine is to be equipped with two eccentrics, so that it may run with equal facility in either direction, they will occupy the positions A and A. We will suppose that an engine having a link motion is to be overhauled and the valve motion to be properly set. This will mean that the eccentrics will be properly located for the correct angular advance, and that the eccentric rods will be adjusted to the right length. When these conditions are obtained, the valve should perform its functions properly in both forward and backward motions, and also when the link is "hooked up."



Before starting to set the valve, it is best to take a general survey of the valve motion parts and see if the eccentrics are somewhere near the proper location on the shaft relative to the crank-pin. If they are obviously much out of position, they should be shifted and adjusted as near the correct position as possible by the eye; doing this at the beginning will often save confusion and much time. The dead centres will be found by the method given on page 228. The operation should be carefully performed, as upon it depends the success of the work. After having found the dead centres and having them marked so that no mistakes will occur when "catching" them with the tram, the valve positions may be taken for the four positions, that is, front and back centres in forward motion, and the front and back centres in backward motion. Put the reverse lever in full gear in one motion or the other, whichever is most convenient and turn the fly-wheel in the direction the engine would run for the given reverse lever position. Suppose the link stands in the position shown in the diagram, the fly-wheel should be turned in the direction indicated by the arrow until the dead centre is reached, which is known when the tram drops into the prick mark. The position of the valve is then noted and a measurement taken. If the valve shows the steam port open, measure the distance with a steel scale, or it may be done by sharpening a stick wedge-shaped and shoving it into the openg. By notiing the depth which it goes at the valve face the opening can be readily measured on the removal of the wedge. We will suppose the distance is found to be $\frac{3}{8}$. The measurement should be set on a sheet of paper laid out as follows:

FORWARD MOTION.	BACKWARD MOTION.
Front centre,	Front centre,
Back centre.	Back centre, $\frac{3}{8}$ lead.

It will be seen that the valve opening is set down as being $\frac{3}{8}$ lead, and as being on the back centre in the backward motion. After having verified the measurement taken, the engine can be "turned over" in the same direction as before until the opposite dead centre is caught by the tram. It may be found that the valve does not show open in this position but covers the steam port. To find the position of the valve edge relative to the steam port, scribe a line in the valve seat face along the edge of the valve and then turn the fly-wheel until the valve uncovers the steam port. The distance the valve laps over when the crank is on this dead centre can then be readily measured. Suppose the distance is found to be $\frac{1}{8}$". It is set down on the log as follows:

FORWARD MOTION.	BACKWARD MOTION.
Front centre,	Front centre, $\frac{1}{8}$" blind,
Back centre.	Back centre, $\frac{3}{8}$" lead.

The valve position is put down as being $\frac{1}{8}$" blind, which is the same as saying that it has $\frac{1}{8}$" negative lead, and is fully as comprehensive as the latter term. The reverse lever should now be thrown into the opposite gear and the measurements taken for both front and back centres the same as has been described for the backward motion. It may now be supposed that when all the measurements have been taken the log reads as follows:

FORWARD MOTION.	BACKWARD MOTION.
Front centre, $\frac{1}{4}$" blind,	Front centre, $\frac{1}{8}$" blind,
Back centre, 5–16" lead.	Back centre, $\frac{3}{8}$" lead.

When in forward motion, the valve is open 5–16" on the back centre and lacks $\frac{1}{4}$" of being open when the crank is on

the front centre. The total lead due to the angular position of the eccentric is $\frac{5}{16}'' \div \frac{1}{4} = \frac{1}{16}''$. One-half the total lead should be given to each edge of the valve so that it will be necessary to lengthen the eccentric rod B, $\frac{1}{32}'' + \frac{1}{4}'' = \frac{9}{32}''$ to get the valve into its proper position. A little reflection will show the reason for lengthening the eccentric rod B. In speaking of the front and back centres, they are taken to coincide with the crank and head ends of the cylinder. When the piston is at the crank end of the cylinder, the crank is on the front centre. By referring to the log it will be seen that to to adjust the backward eccentric rod B′, it will also be necessary to lengthen it. The valve is $\frac{1}{8}''$ blind on the front centre and has $\frac{3}{8}''$ lead on the back centre. The total lead is, therefore, $\frac{3}{8}'' \div \frac{1}{8}'' = \frac{1}{4}''$. One-half $\frac{1}{4}'' = \frac{1}{8}''$, which being added to the amount the valve is lapped on the front centre, makes $\frac{1}{4}''$, or the amount the eccentric rod B′ will have to be lengthened to make the valve open equally at each end of the piston stroke. The opening the valve has when the crank is on the centres is called the lead and in the case of the backward motion, it is found that after the eccentric rod is lengthened, the lead is $\frac{1}{8}''$, which is too much for the most cases and in this one we can assume that $\frac{1}{32}''$ would be about right.

Before explaining the adjustment of the eccentric for the correct angular advance, it will be in order to call attention to the necessity of making the adjustment for the eccentric rod lengths first. The eccentric rods are lengthened or shortened, as the case may require, by inserting or removing liners between the eccentric rods and straps at R. Other forms of construction provide different means for adjustment, but the principle is the same in each. It will be noted that the correct length for the two motions is obtained by adjusting the eccentric rod corresponding to that motion. Any attempt to correct an irregularity by changing the length of the valve rod F will result erroneously, unless both eccentric rods require the same amount of movement and in the same direction. After having adjusted the eccentric rods to the correct lengths, the angular advance of the eccentric A can be changed. Place the crank on a dead centre and have the reverse lever thrown in the backward motion and then loosen the set screws that hold the eccentric to the shaft and turn it towards the crank until the valve shows open $\frac{1}{32}''$, and then tighten the set screws on the shaft. After all adjustments have been effected, it is always advisable to turn the engine over again and catch all the dead centres so that the correctness of the adjustments can be verified. After taking the new log, it will usually be found that some slight irregularities have been introduced, especially if any of the adjustments have been considerable, as the changes made for one motion will affect the other slightly.

The link motion shown in the cut is so connected that the lead increases as the link is shifted towards the centre. If the eccentric rods be oppositely connected to the link, the engine will run in an opposite direction for a given reverse lever position and the lead will decrease as the lever is shifted towards the centre. The link motion for hoisting engines is quite commonly connected in this manner, for the reason that the engine will stop when the lever is put in the centre which is not the case when connection as shown. Of course, in such a case, the admission and cut-off take place at the same position in the stroke and the compression is high, but with a light load the engine will run on the centre, which is considered objectionable in the case of the hoisting engine.

The Planimeter

By Thos. G. Keogh.

The mechanical Integrator or Planimeter, has a peculiar fascination for the mechanical mind, for aside from the labor saving quality which most of them possess they represent complexity of thought expressed in mechanism.

The history of the instrument does not seem to be generally known.

The first mechanical method of rectifying a curve, as it is called—that is, obtaining its length—was by rolling a wheel along it, this wheel was connected with a suitable train of wheels for recording the total number of revolutions, the rolling wheel being either a unit in length or containing a known relation to this unit. The use of such an instrument is very ancient and is mentioned in the tenth Book of Vitruvius.

The first recorded idea of a modern Planimeter is credited to Herman of Munich, and was published in 1814. In 1827, Oppikefer of Berne presented one on similar lines, following closely on this. Professor T. Conella, of Florence, in 1828 presented an instrument almost identical, without any knowedge of what had been done by his predecessors. Oppikefer in conjunction with a Swiss mechanic named Ernst, finished a Planimeter which won a prize in Paris in 1836.

Wettli, of Zurig, and Starke, in 1849 perfected and patented the instrument now known as the Wettli-Starke Planimeter. Hausen, in 1850, still further improved this instrument and in conjunction with Ausfeld, introduced a different method of reading. In 1852 Sang invented an instrument using a cone instead of a disc. In 1856 Professor Amsler-Laffon invented the well known polar Planimeter bearing his name. Professor Miller, of Leoben, also invented a Planimeter of this kind in the same year.

Previous to this in 1854–5, Decher, of Augsberg, and Bowniakovsky, of St. Petersburg, had improved on existing forms. Recently a large number of precision polar planimeters have been designed, combining the various principles of action of former types.

In 1882, Mr. Hohman Bauamtman, of Bamberg, in conjunction with Mr. Coradi, of Zurich, were about the first to construct the precision instrument, the accuracy of which was most remarkable, reading to within .0005 of a square inch and with skillful use not varying over one or two vernier units on retracing the same area. The test disc of this instrument if immersed in ice water and the tracer point run around it and the same be done when it has been taken out of boiling water, the expansion of the disc will be plainly shown by the increased reading of the instrument.

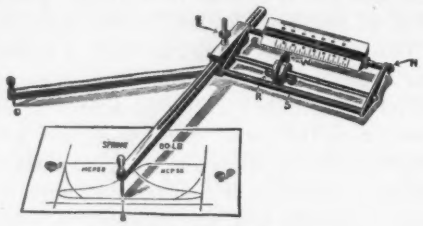
Instruments of high efficiency, like the above, are used to find static moments or moments of inertia, and are so arranged as to give the displacement of vessels from scale drawings.

In all Planimeters in which the recording wheel travels on the paper, whether rotary or sliding, the wheel movement equals the area traversed divided by the length of tracer arm, all three to be measured by the same unit. Thus with a tracer arm one foot long, the Planimeter should give a wheel movement of one foot on tracing an area of one square foot. All that would be necessary is that the same scale be used to measure the wheel movement that was used on the drawing.

This practically described the instrument invented by Edward J. Willis, M.E. This instrument combines with simplicity of construction on almost marvellous accuracy,

and while it gives areas of regular or irregular diagrams it also gives the M.E.P. of indicator cards without any computation.

This instrument works on somewhat different lines from most other Planimeters. The ball bearing wheel (W) rolls for all movements parallel to the tracer bar and its two rollers (R and S), permit it to glide along the triangular steel shaft for all perpendicular movements. After tracing a figure the result is read from the scale next to the wheel. This scale is



Willis Planimeter.

triangular, and having six graduations, any one of them can be brought next the wheel.

The recording wheel of this Planimeter has a sharp edge which takes firm hold upon the paper or material upon which the instrument is operated and the rollers (R and S), bear the weight of the instrument, allowing the wheel to glide freely on the steel shaft, making the instrument practically frictionless.

The rotary movement not being registered, it is plain that the accuracy of the instrument is not affected by the character of the surface upon which the instrument is operated or by any change in diameter of wheel or injury to the knife edge. This is one of the most important points to be considered in the selection of a Planimeter.

In regard to Planimeter accuracy it is to be remembered that a scientific result is no more accurate than the most uncertain factor in its calculation, no matter how far the results may be given in decimal figures, any figures beyond those which are justified by the accuracy of the most uncertain step of the process are meaningless and vary with chance.

Drawing paper of good average quality will in a variable atmosphere vary in length at least one-fourth of one per cent. Tracing papers also vary as much, so that to read to 1-100 of one per cent. even on a well made drawing, is a refinement hardly to be expected.

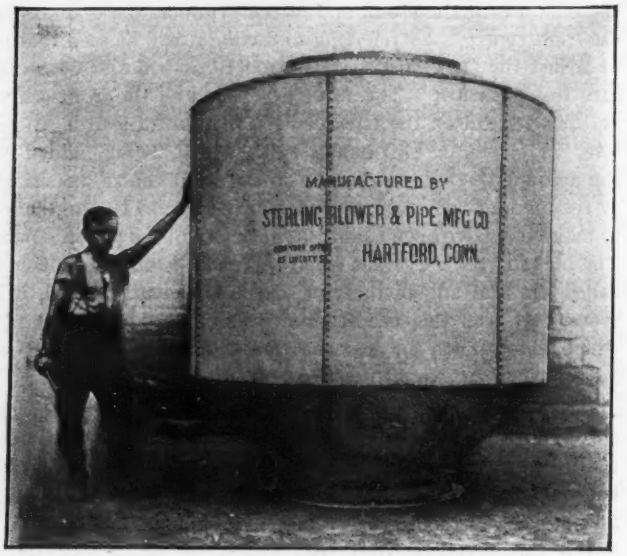
A Serious Accident to Brother Kirkwood

On Thursday, August 6th, P. A. Kirkwood, chief engineer of M. V. Smith & Son's Refrigerator plant, met with an accident in which he lost his right arm. Mr. Kirkwood had but recently been appointed to the position of chief, having been for some time past assistant engineer at his present place.

The accident occurred after he had completed some repairs to the engine and had started it up; after closing he placed his hand upon the bearings and it became entangled in the govenor gearings, lacerating it so badly that immediate amputation was necessary. Mr. Kirkwood is a member of Energy Council of the A. O. S. E., Baltimore, Md., members of which used their every endeavor to assist the brother in his trouble. In order that the company should be at no loss during Brother Kirkwood's incarceration in the hospital, Supreme Chief Noah R. Pierson and Brothers Dietrick, Stallings, Smithers and McGee assumed control of the plant alternately and run the plant with no loss of time to the firm which they appreciate highly.

Some Big Exhaust Heads

The cut shown herewith is that of a 36-inch exhaust-head made by the Sterling Pipe and Blower Manufacturing Company, of Hartford City, Conn., for the Springfield Street Railway Company, of Springfield, Mass. This company have also just received orders for two 36″ heads for the Rhode Island Suburban Railway Company, of Providence for their new



36-inch Exhaust Head for Springfield (Mass.) Street Railway Company's Power House.

power house and also for all the heads for the new Bellvue-Stratford Hotel, now in course of erection at Philadelphia. These heads stand 90″ high and are 80″ in diameter, they are built of heavy galvanized sheet steel, closely rivited and well soldered.

The Secor Kerosene Oil Engine

To obtain power directly from fuel, by means of a practical process embodied in a self-contained automatic machine, requiring neither boiler nor fireman, is a problem that has baffled the ablest engineers. The direct application of heat to the engine would quadruplicate our power, as a machine, the steam engine is almost perfect, yet it wastes 85 to 95 per cent. of the heat units of coal; it is economical in the use of steam, yet steam is an extravagant agent by which to utilize the heat power of fuel.

The General Power Company offers the Secor oil engine as a practical solution of the problem of generating power by direct process. Criticism from the steam engine viewpoint shows, unquestionably, that this engine combines the advantages of the steam engine, with the thermodynamic and labor-saving advantages of the gas engine.

A personal experience will fully bear out and illustrate the advantages of the above system. Messrs. Houchin and Huber, of 53d Street, Brooklyn, three years ago installed a 12 h.p. Secor oil engine which replaced a 12 h.p. steam engine.

This engine occupies a space 42″+62″, runs ten hours daily, with an average consumption of twelve gallons, costing, $1.20. (The price of oil is 10 cents per gallon.) Kerosene is obtainable everywhere, and is safer than gasoline, the sale of which is restricted.

This engine at full load drives the following rather formidable list of machines, which the old steam engine failed in quite frequently, necessitating the stoppage of two and three machines to ease up.

Three saws, one planer, two boring machines, in the wood working department.

Five lathes, three drill presses, one router, one slotting machine, one shaper, one planer, and other small machines in the machine shop. Also a small dynamo.

During its three years' work it has never failed, nor required repair.

The firm testify that the regulation of oil consumption was very good, fluctuating with the demands made upon it by power requirements, and such months as our work runs light, the oil bill reflects the fact accordingly.

The manufacturers certainly claim no more than the engine performs, rather to the contrary as the above example shows the engine is overloaded.

It is remarkably quiet in its action, no fussing or disagreeable puffing. The smell of oil is conspicuous by its absence, proving it to be a perfect internal combustion engine. The oil and air are inhaled at the same temperature, thus ensuring the perfect conditions of a single gaseous compound.

These engines are manufactured by the General Power Company, 81–83 Fulton Street, New York City.

H. Matteson, Jr., 690–692 Bourse Building, is their Philadelphia representative.

The Thompson Damper Regulator

The accompanying illustrations show an improved form of damper regulator manufactured by Richard Thompson & Co., 126 Liberty street, New York, who have long been selling agents for a machine of this type. The knowledge thus acquired by practical experience has enabled them to introduce several modifications, together with new and important

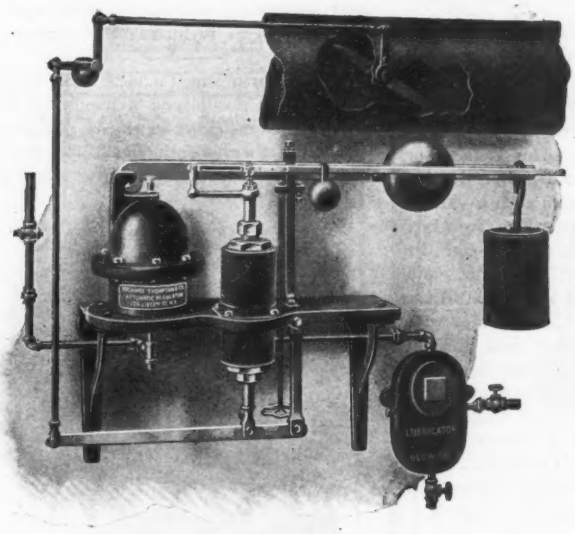


Fig. 1.

improvements which they consider very desirable. The flaring body between the diaphragm flanges and the flat frame has been changed to cylindrical form, as shown in Fig. 1. This reduces the width of the frame by over two inches and brings the cylinder and all forking parts nearer to the wall on which it is mounted. A new lubricator is also shown in Fig. 1. The water comes to the regulator through this device in which is a caged receptical for holding a piece of hard soap or borax, which softens the water and lubricates the valve.

The valve and piston have been changed as shown in Fig. 2. The water pressure enters at "A". When the valve moves downward, pressure is admitted to the port "B," acting on the upper end of the piston and forcing it downward at the same time water from the lower end of the cylinder is forced up through port "C," where it comes in contact with port "D," through which it flows into and through the by-pass "E"

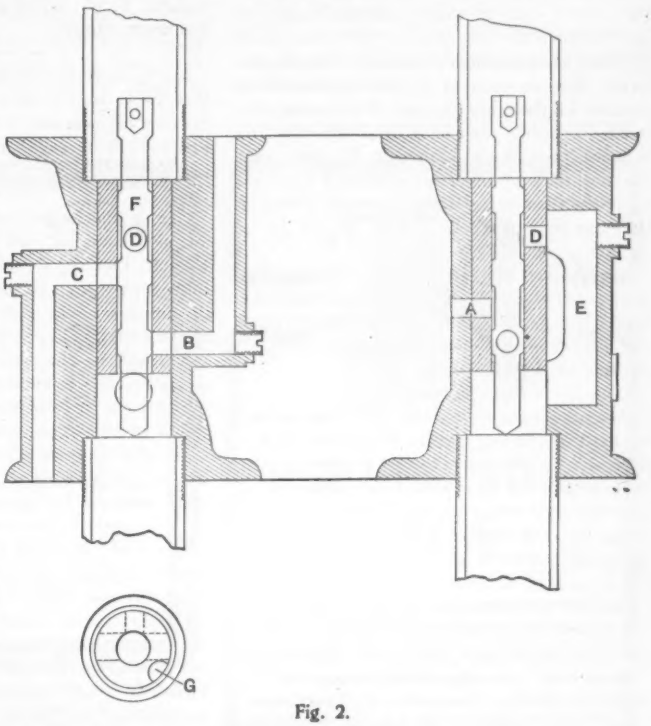


Fig. 2.

thence through the drip. When the valve moves upward, pressure is admitted to the port "C," forcing the piston upward. Water from the top flows through port "B," thence to the drip. The valve is provided with an extra seat "F" which prevents water from discharging or passing out at the top of valve stem. Such leakage as passes the upper valve seat "F" finds its way through passage "G" to the drip. This passage is in a heavy bushing in which the valve works. The valve and bushing are made of special metal and can be renewed and replaced should it become necessary. The plugged openings in the valve body give access to the ports. The valve lever is shown in Fig. 3. The enlarged portion into which the valve rod connects being of sufficient size to permit the withdrawing of the valve by taking out the herled screw without disconnecting the lever.

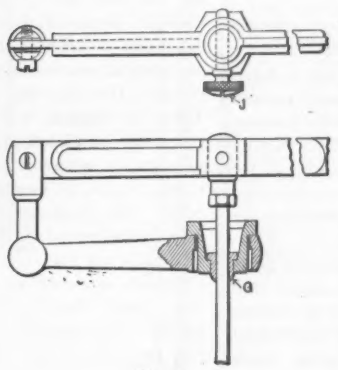


Fig. 3.

TRADE NOTES

"Points on Packing" is the title of a very interesting booklet just issued by that ever popular house, "Jenkins Brothers." It contains very many points of value to the engineer and can be had for the asking. Address Jenkins Bros., 133 North Seventh Street, Philadelphia, Pa

"The Lunkenheimer Company, Cincinnati, report that on account of the unprecedented demand for their superior line of brass and iron steam specialties, they have been compelled to increase their foundry output 50 per cent. Machine tools of the most improved type are being installed in varous departments as fast as they can be obtained."

The Quaker City Rubber Co., Philadelphia, have a very nice steel rule made specially for measuring packing, which they offer to send free to any engineer who orders enough "P.P.P." packing for a trial.

A steam separator inside the boiler is a novelty to most engineers, but it is evident that a separator at the engine has to tax its capacity to take care of the steam pipe condensation. A letter addressed to John Lindstrohm, Allentown, Pa., will obtain for the writer a catalogue upon this subject.

We call the attention of our readers to the advertisement on page 54 of this issue, setting forth the merits of a white sheet packing, the "Searchlight" brand, manufactured by The Republic Rubber Company, of Youngstown, Ohio. This Company has already established a large number of agencies for the distribution of this packing throughout the United States. The Mulconroy Company, of 1213-15 Market Street, are sole agents for Philadelphia and vicinity, and carry a full and complete stock in all thicknesses.

Although the packing has been actively pushed but a short time, the demand is already large. The value of the packing is said to have been fully demonstrated under most severe tests at the Company's factory and the hardest kind of usage that could be found in various manufacturing plants before it was offered for universal use. It is but natural therefore that the packing should be received with favor by engineers generally.

Mr. L. J. Lomasney, the Company's Sales Manager, informs us that each engineer will shortly receive a very pretty folder of striking design setting forth the merits of Searchlight Packing. An elegant transparency in water color will be mailed to any engineer free of cost upon application.

Owing to the rapidly increasing demand for their goods and the consequent lack of space at their old quarters, the firm of W. Clifford Smith has removed to 140 North Sixth Street, where they will have a much larger and better place. In their new quarters they will carry a large line of grate bars for the accomodation of their engineer friends, they will also carry a large stock of Smith's Patent Pipe Clamps, which has recently been greatly improved. Engineers are invited to call or write for circulars.

A Feed Water Heater that removes the oil from the exhaust and heats the feed water to 210 or 212 degrees at the same time seems like a pretty good thing; this is what the Otis heater is said to do. It is manufactured by the Stewart Heater Co., 11 Norfolk Avenue, Buffalo, N. Y. Catalogue and prices will be sent upon request.

Jas. L. Robertson & Sons, 205 Fulton Street, New York, want to send one of their catalogues to every engineer who is interested in Indicators, Planimeters, or any of the many steam specialties described therein.

One of the largest contracts recently made for pipe covering, has just been awarded to John R. Livezey, General Agent for Nonpareil Cork, for covering all the steam and brine pipes in the new Bellvue-Stratford Hotel now in course of erection in Philadelphia. This hotel, which will be the handsomest in the city is owned by Mr. Boldt, who also owns the Waldorf-Astoria in New York, the steam pipes of which were covered with Nonpareil Cork when it was erected some seven years ago, and which has proven so efficient that nothing but cork was considered for the new Philadelphia house.

The Geo. W. Lord Co., 2238 North Ninth Street, Philadelphia, inform us that they now have the most elaborate and efficient chemical laboratory in the world devoted exclusively to the treatment of water for boiler feed. In it is included every modern instrument or method known to science for determining the chemical composition of water, or boiler scale. A sample of scale sent them by any of our readers will be analyzed and a certificate of analysis furnished free of cost.

Teon Belt, six ply, has a tensile strength of one ton per inch of width. This is food for thought, moreover, leather and rubber belting is subject to deterioration from such a variety of chemical conditions against which Teon belt is proof that it is well worth while to consider Teon, for almost any kind of service, and especially for places where it is exposed to the weather, or where it comes into contact with steam, water, ammonia, caustic soda, lime or acids. The claims made for this belt may seem rather strong, but it should be remembered that they are the result of actual usage under all kinds of conditions. D. P. Brown & Co., 264 North Fourth Street, Philadelphia, will furnish any special information desired, or will mail one of their booklets upon request.

The Keystone Lubricating Co., Twentieth and Allegheny Avenue, Philadelphia, have recently received a report of a chemical analysis of Keystone Grease made at Sibley College, Cornell University. The report shows that no harmful ingredients or adulterants such as Mineral Acids, Resin Oil, Talk Chalk, etc., enter into its composition, but the company do not ask engineers to accept even this high grade testimony as proof of the value of their product, they are still offering to send a large sample can of Keystone Grease and a Keystone Brass Cut free', to any engineer or steam user in the world, express charges prepaid, so that they may give it a thorough trial for themselves.

On the 15th of July the Penberthy Injector Company, of Detroit, Michigan, placed the number 300,000 on one of the "Penberthy" automatic Injectors, having completed this number of injectors in just a little over sixteen years. They rightly consider that this is a most remarkable record, especially when it is taken into account that it took nearly ten years of hard work to convince engineers that an automatic Injector was a practical device, and to manufacture and sell the first 100,000 machines. It is somewhat difficult to comprehend what is meant by 300,000 Injectors. Possibly the following facts may help to an understanding of the subject. Basing the figures on the average capacity of the Injectors sold during the past twelve months, the 300,000 "Penberthy" automatic Injectors on the market will handle in one hour 109,500,000 gallons of water. This amount of water if pumped into an upright tank fifty feet square would require the tank to be over a mile high, or to put in another way, if the output of these 300,000 Injectors were combined into one stream they would supply a river ten feet deep, and 250 feet wide, and keep up a steady flow of water at the rate of a little over one mile per hour. If the 300,000 Injectors were all connected to one source of water supply, they would in ten hours completely drain a lake ten feet deep, one mile long and a half mile wide. The company also manufacture the Penberthy Auto-Positive hot water, high pressure, restarting Injector, information regarding which they will be glad to furnish any inquirer.

The Walworth Mfg. Co., 128 Federal Street, Boston, Mass.., will send a handsome match safe like the one shown in cut, to any engineer who writes them mentioning "The Practicai Engineer," provided he will also state where

and by whom they are employed as engineer. Those who wish these handsome little prizes should write at once as the supply is limited.

Every engineer knows the Peerless Rubber Mfg. Co., 16 Warren Street, New York, if for no other reason he knows them because they are the manufacturer of the famous Rainbow Packing, it is therefore fair to presume that most engineers will be interested in a new catalogue of Engineers' Specialties No. 58, just issued by the company, it contains forty-four pages, descriptive of specialties interesting to engineers, is printed in colors and handsomely illustrated. Copies will be mailed free to engineers who request them mentioning "The Practicai Engineer."

James McCrea & Co., Chicago, Manufacturers of Steam Specialties, report the sales of their H. H. Steam Trap have crowded their capacity for turning them out to the extent of their having to install several new machines, which will about double their facilities for making prompt shipment in the future. They claim this trap to be the simplest in operation and and less liable to get out of repair than any trap on the market to-day, and they feel their claims are substantiated by the enthusiasm shown by the trade in adopting it.

The Lagonda Manufacturing Company, of Springfield, Ohio, inform us that they have received a letter from the Union Waxed and Parchment Paper Company, of Franklin, Ohio, in which they claim to have effected a saving of twenty per cent. in their full bill through the use of a Weinland Tube Cleaner, in the tubes of a battery of four B. & W. water tube boilers.

IF ENGINEERS will send $1.00 to the address below they will receive two blue prints, with tables and instructions, showing how to set valves and eccentrics on Corliss engines, simple and compound, with one and two eccentrics. JOHN T. LINDSTROM, 214 and 216 S. 3d St., Allentown, Pa.

The Sims Company, Erie, Pa., report that they have had a number of duplicate orders this month for their "Sims" Steam Separators. This is the best kind of evidence that as these articles become better known, the r merits are appreciated.

The Dearborn Drug and Chemical Works, of Chicago, have opened an office in the Bourse Building, Philadelphia, with Mr. W. T. Johnson in charge. Mr. Johnson, though not a native of the Quaker City is well and favorably known to engineers almost everywhere in the East and South, having been with the Crosby Steam Gauge and Valve Company, of Boston, for the past three years, and for ten years prior, with the Mason Regulator Company, as traveling salesman.

About a year ago the France Packing Company added a new department to their business for the manufacture of all kinds of soft packing, and for some time have been in a position to supply their many engineer friends with all the packing they require. They have said little about the merits of this new packing preferring to give its users ample time to test it under every condition. That the results have proved satisfactory is being constantly vouched for by the duplication of orderr. Further information in regard to prices, etc., will be furnished on application to France Packing Company, Philadelphia. They will also be glad to furnish you with some interesting facts about the success of their metallic packing on ammonia rods.

BEFORE YOU BUY AN OIL FILTER

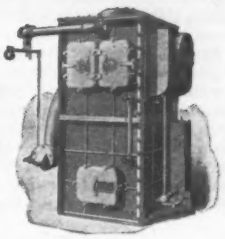
Send for our booklet, and find out all about the

CROSS OIL FILTER

Then you are sure to buy one of ours' because it is the best on the market.

The C. T. Roentz Leather Co., of Sheboygan, Wis., say: "We put the Cross Oil Filter on trial with two other makes, gave them a thorough test, and kept yours. We are well pleased with it.

THE BURT MFG. CO., AKRON, O., U.S.A.
Largest Manufacturers of Oil Filters in the World.
Cross Oil Filters carried in stock by the
FAIRBANKS CO.
Sole Agents for Philadelphia



A COCHRANE HEATER SAVES

The best argument in favor of a Cochrane Feed-Water Heater is that the results of its savings can nearly always be measured in *money*. A Cochrane Heater saves coal, and you can see the difference in your coal bills. A Cochrane Heater saves boiler feed water, and when you have to pay for your feed supply, the difference in the quantity used, and the difference in the cost, are appreciable. A Cochrane Heater materially improves the quality of the feed water, and in other ways decreases the wear and tear on boilers, (for instance, it eliminates expansion and contraction strains by delivering hot water to the boilers), and when you note the absence of shut-downs for repairs, and the prolonged life of your boiler you can easily figure out that the heater has saved you money, and made extra profit possible by keeping expenses down.

A Cochrane Heater brings into actual contact the exhaust steam and the water to be heated—nothing between the two to retard in any degree the transmission of the heat to the water. It is no trouble to get the feed-water up to 210° or 212° when the exhaust is available. Day after day, month after month, year after year, it gives this service. There are no heating surfaces, such as coils or tubes, to become coated with scale. How *can* it foul up as a closed heater would?

If you are in the market, a full investigation of these Cochrane Heaters, as to their design, construction, and accomplishment in actual service, is all that will be needed to convince you that the Cochrane is the one you ought to have.

Send for **Catalogue 16-H.**

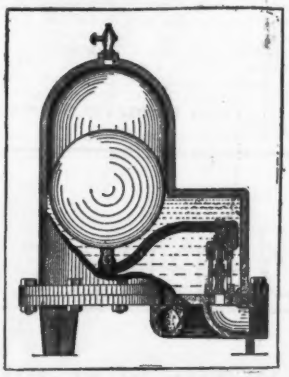
Harrison Safety Boiler Works

3144 North Seventeenth St.

PHILADELPHIA, PA.

Manufacturers of
COCHRANE STEAM AND OIL SEPARATORS,
and of the SORGE-COCHRANE SYSTEMS.

A GOOD THING



The "FORD" Compound Steam Trap

We want you to take hold of it. Made in 5 sizes. Has large outlet and the largest capacity of any Steam Trap on the market.
Write for full particulars and prices.

Thomas P. Ford Co.
SCHADE & MARSHALL
PHILA. AGENTS
319 HARRISON BUILDING PHILADELPHIA, PA.

Dixon's Flake Graphite adds to the lubricating power of any grease and any oil greatly out of proportion to the amount used. Actual test shows that one-seventh of the lubricating graphite added to the oil increases the lubricating power one-half. Ask for booklet 96-c.

Joseph Dixon Crucible Company, Jersey City, N. J

American Order of Steam Engineers.

ORGANIZED APRIL 27, 1886.

An Order of Engineesr for Engineers and Engineers only.

DECLARATIONS OF PRINCIPLES

Believing that ability will bring its full value in this country, this Order shall at no time take part in strikes, nor in any way interfere between employer and employees. Recognizing their identity of interests, it shall take no part in any project or enterprise that shall interfere with perfect harmony between them ; neither shall it be used for political or religious purposes.

These principles shall not be amended or repealed except by unanimous vote of the Order.

Any member who shall be guilty of violating the principles of the Order shall be expelled.

OBJECTS.

First.—To promote a more thorough knowledge in its members of theoretical and practical steam engineering.

Second.—To assist members to obtain employment.

Third.—To help the sick, injured and distressed and bury the dead.

Fourth.–To establish a Widows' and Orphans' Fund.

Fifth.—To help members who shall become incapacitated from following the profession to obtain employment suited to their affliction.

Sixth.—To do our utmost to extend the license law throughout the United States.

Seventh.—To establish schools in which our members may study the highest branches of steam engineering.

MEMBERSHIP.

An applicant for membership must be an engineer between twenty-one and fifty years of age, and must be a white male citizen of the United States, of good moral character and be a believer in the Supreme Being, and be free from all physical infirmities.

He must have had three years' service in an engineering department, or if a machinist, or graduate of a technical institute, then one year's service, in such department, and in localities where engineers are required by law to be licensed, they must have such license, and must satisfy the investigating and examining committees of the council to which he applies as to his character and ability.

LIFE MEMBERSHIP.

Engineers who have passed the age limit may be admitted to life membership. They must possess the same qualifications and pass the same examination as are reqnired in the next proceeding clause: They shall be entitled to all rights and privileges of the Order except they cannot vote on financial questions or for the election of officers or be entitled to any sick or death benefits.

DIRECTORY.

The Publication Committee of "The Practical Engineer" desires that the Corresponding Engineers of all Councils of the American Order of Steam Engineers send the name of their Chief Engineer and their own name and address, together with the time and place of meeting, to the Secretary of the Publication Committee immediately after each election of officers. Address J. C. McDowell, Secretary, in care of "The Practical Engineer," 1215 Filbert Street, Philadelphia.

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Deputy Supreme Chief Engineer, David J. Stayton, No. 513 Searles St., Wilmington.

WILMINGTON.

Delaware Council, No. 1, meets every Wednesday at S. E. Cor. Fourth and King Sts. Chief Engineer, Clark Franklin. Corresponding Engineer, A. E. Deakyne, 406 Lombard St.

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Deputy Supreme Chief Engineer, John W. Angers.

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JENNINGS.

Jennings Council, No. 2, meets every Saturday evening in American Bank. Chief Engineer, Daniel R. Jones. Corresponding Engineer, R. E. Funk.

MARYLAND.

Deputy Supreme Chief Engineer, A. J. Deffrich, 226 North Caroline St., Baltimore, Md.

BALTIMORE.

Maryland Council, No. 1, meets 2nd and 4th Fridays in Royal Arcanum Hall. Chief Engineer, L. Smithers. Corresponding Engineer, Wm. S. Smith, 533 Sharp St., Baltimore.

Energy Council, No. 2, meets every Wednesday of each month in Bauer Hall, Chesapeake and Elliott Sts. Chief Engineer, T. E. Eaton. Corresponding Engineer, Thos. O. Daneker, 834 East Ave.

MASSACHUSETTS.

Deputy Supreme Chief for Eastern District, W. E. Packard, Whitmann.

BOSTON.

Boston Council, No. 4, meets 2nd and 4th Thursdays of each month, in Templar Hall, 724 Washington St. Chief Engineer, A. R. Abbott. Corresponding Engineer, Phillip Sanford.

ROCKLAND.

Old Colony Council, No. 14, meets 2nd and 4th Saturdays in the American Foresters' Hall. Chief Engineer, Herbert W. Jones. Corresponding Engineer, James K. Sedgwick, Box 233, Rockland, Mass.

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Deputy Supreme Chief, F. O. Garrison, Bridgeton, N. J.

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Stevens Council, No. 1, meets 3rd Saturday, at Water, near Lafayette St. Chief Engineer, Lawrence Oliver. Corresponding Engineer, James H. White.

CAMDEN.

Camden Council, No. 3, meets every Thursday evening at S. E. corner 2d and Arch Sts. Chief Engineer, S. M. Best. Corresponding Engineer, C. H. Pfeiffer, 571 Berkley St.

ATLANTIC CITY.

Atlantic City, No. 4, meets every Tuesday evening at Merchants, Cor. Atlantic and New York Aves. Chief Engineer, John A. Best. Corresponding Engineer, W. S. Price, Haddon Hall.

BRIDGETON.

Bridgeton Council, No. 5, meets every Friday. Chief Engineer, David Sellers. Corresponding Engineer, Francis O. Garrison, Bridgeton, N. J.

MILLVILLE.

Millville Council, No. 6, meets every Saturday, 7.30 P. M., in G. A. R. Hall, East Main St. Chief Engineer, Wm. F. Pond. Corresponding Engineer, Lewis Doughty, 604 Mulberry St.

NEW YORK.

SYRACUSE.

John E. Sweet Council, No. 6, meets Monday, Room 23, Nottingham Block, East Washington St. Chief Engineer, John Cunningham. Corresponding Engineer, S. A. Steel, 311 Orange St.

PENNSYLVANIA.

Grand Chief Engineer, Hiram Trout, 1042 Locust St., Reading, Pa. Deputy Grand Chief for Philadelphia and Delaware Counties, John P. Rickards, 2707 N. Broad St., Philadelphia. Grand Corresponding Engineer, Frederick Markoe, 931 Orianna St., Philadelphia.

Deputy Grand Chief for Western Pennsylvania, A. D. Hamilton, 2025 Forbes St., Pittsburg, Pa.

PHILADELPHIA.

Germantown Council, No. 22, meets every Wednesday evening at Main and Seymour Sts., Germantown. Chief Engineer, George T. Lee. Corresponding Engineer, Frank MacIndoe, 3519 Ainsley St., Falls of Schuylkill, Philadelphia.

Welcome Council, No. 2, meets every Friday, N. W. Cor. Twelfth St. and Columbia Ave. Chief Engineer, Paul Pieling. Corresponding Engineer, L. D. Woodington, 2428 N. Bancroft St.

Kensington Council, No. 3, meets every Thursday, at A. P. A. Hall, Frankford Ave. and Master St. Chief Engineer, Ed. C. Ricker. Corresponding Engineer, Ernest Ritsert, 2229 Frankford Ave., Philadelphia.

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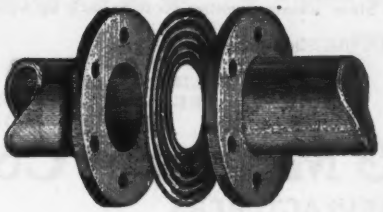
TRADE MARK
TRI-SODIUM PHOSPHATE
INCREASED BOILER EFFICIENCY
DECREASE IN THE FUEL BILL
REGISTERED
WITHOUT INJURY EITHER TO THE BOILER OR THE PRODUCT
This and a lot more about its prolonging the life of the boilers, is the story its users have to tell. Would you like to know what it would cost to keep your boilers clean? Send us a gallon of your feed water, the analysis free. So is our Booklet "WORTH KNOWING."
THE KEYSTONE CHEMICAL MFG. CO., CAMDEN, N. J.

The Standard Gasket Co., Inc.



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We also Manufacture Special Metal Gaskets for all Styles of Water Tube Boilers, Man- and Hand-Hole Plates, Mud Drums Etc., which can be used over many times. We guarantee to save you 50 per cent. on any Gaskets your now use.

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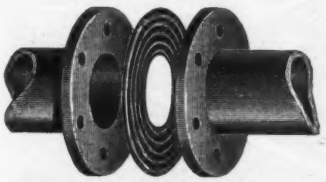

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UNITED STATES MINERAL WOOL CO.

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BEST AND CHEAPEST SAMPLES FREE

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LUBRICATOR

illustrated here is designed for Single Engines or Large Plants where many Engines are operated from one steam main. It will oil one or a dozen Engines, save 40 per cent. of Oil used with any other Lubricator, and prevent annoying leaks in Steam Pipes.

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Lackawanna Lubricator and Mfg. Co.

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An old engineer from the West,
Who had put "P. P. P." to the test,
Says "It saves work and power,
And fuel each hour,
And outlasts any two of the rest.
(P. S.—And that's why I say it's the best.)

An enormous waste is the loss of power from solid packings. Your competitors have stopped this waste by using

DANIEL'S "P. P. P." PACKING

Instead of holding the rod in a tight grip as solid packings do, the sliding wedges of P. P. P. adjust themselves to the rod with the least possible pressure. What it saves in fuel is told by Mr. Geo. T. Gilbert, Chief Engineer for Forbes & Wallace, Springfield, Mass., who says:

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Southwark Council, No. 4, meets every Monday, at Cor. of Reed and Eighth Sts. Chief Engineer, Hugh Ryder. Corresponding Engineer, J. C. McDowell, 1913 South Eighth St.

Philadelphia Council, No. 7, meets every Wednesday, at Kenny's Hall, N. W. Cor. Broad and Filbert Sts. Chief Engineer, Harry Dunn. Corresponding Engineer, W. S. Wetzler, 3717 Aspen St.

Manayunk Council, No. 9, meets 2nd and 4th Friday evenings in Temperance Hall. Chief Engineer, Andrew Roberts, Sr. Corresponding Engineer, John Clevenger, 211 Lofty St.

Helping Hand Council, No. 12, meets every Thursday evening at Kensington Ave. and C St. Chief Engineer, Edward Laurence. Corresponding Engineer, Frank McHugh, 2503 Tulip St. All correspondence should be addressed direct to the Council.

Municipal P. F. D. Council, No. 20, of Philadelphia, meets the second Thursday of each month at Odd Fellows' Hall, Third and Brown Sts. Chief Engineer, Daniel Bunting. Corresponding Engineer, Walter Meyers, 1211 North Howard St.

PITTSBURG.

Iron City Council, No. 21, meets every Saturday at Arnfeld Hall, 1119 Penn Ave. Chief Engineer, J. J. Stewart. Corresponding Engineer, Alex. Fraser, Carnegie, Pa.

GIRARDVILLE.

Girard Council, No. 8, meets every Tuesday evening at O'Neill's Hall, Second and Ogden Sts. Chief Engineer, Jacob Weber. Corresponding Engineer, M. J. Carey, Lock Box 214.

ALLENTOWN.

Lehigh Council, No. 15, meets every Wednesday evening at 639 Hamilton St. Chief Engineer, John evening at 639 Hamilton St. Chief Engineer, Henry C. Snyder. Corresponding Engineer, A. P. Driesbach, 728 Chew St.

POTTSTOWN.

Pottstown Council, No. 14, meets 1st and 3rd Saturday evenings at P. O. S. of A. Hall, Cor. High and Hanover Sts. Chief Engineer, Chas. Quinter. Corresponding Engineer, H. L. Shirey, 362 Cherry St.

READING.

Progress Council, No. 13, meets every Saturday evening at Diebert Hall, Ninth and Penn Sts., Room 4. Chief Engineer, John Kellenberger. Corresponding Engineer, Frank S. Miller, 3 West Franklin St.

CHESTER.

Delaware County Council, No. 6, meets every Wednesday evening in the Carpenter Hall, Sixth and Wall Sts. Chief Engineer, John Canavan. Corresponding Engineer, E. E. McCoy, 2222 West Third St.

YORK.

York Council, No. 16, meets every Wednesday Evening in the Jordan Block. Chief Engineer, A. L. Bair. Corresponding Engineer, Walter H. Long, 23 East Philadelphia St.

HARRISBURG.

Capitol City Council, No. 17, meets every Tuesday evening in Red Men's Hall, Market St., above Second. Chief Engineer, B. H. Shafer. Corresponding Engineer, S. Filson, 1126 Market St.

COLUMBIA.

Columbia Council, No. 18, meets every 1st and 3rd Saturdays, in Odd Fellows' Hall. Chief Engineer, John McLane. Corresponding Engineer, W. J. Courtney, 804 Walnut St.

SUNBURY.

Sunbury Council, No. 19, meets every Monday evening in Zartman's Hall. Chief Engineer, R. D. Mantz. Corresponding Engineer, Ed. Schrieber.

WISCONSIN.

Deputy Supreme Chief Engineer, Joseph P. Harris, No. 1611 Clybourn St., Milwaukee.

MILWAUKEE.

Washington Council, No. 1, meets every Saturday at 207 Grand Ave. Chief Engineer, J. B. Chambers. Corresponding Engineer, James A. Rigby, 136 Reed St.

Clifford P. Williams Council, No. 2, meets every Monday evening at Lodge Hall, E. Water St. Chief Engineer, J. T. Harris. Corresponding Engineer, Joseph T. Harris, 1611 Clybourn St.

TENNESSEE.

Deputy Supreme Chief Engineer, John B. Mullen, 826 Central Ave., Nashville.

NASHVILLE.

Enterprise Council, No. 1, meets every Friday evening in the Twin Building on Cedar St. Chief Engineer, J. J. Johnson. Corresponding Engineer, Jno. B. Mullen, 209 Jackson Building.

OREGON.

Deputy Supreme Chief Engineer, Nat. Freese, Grant's Pass, Oregon.

GRANT'S PASS.

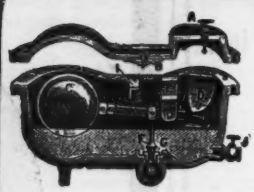
Oregon Council, No. 1, meets every 1st and 3rd Saturday in A. O. U. W. Hall, Main St. Chief Engineer, William H. Kenny. Corresponding Engineer, Nat Freese.

TEXAS.

Deputy Supreme Chief Engineer, S. A. Bisbey, care of Cotton Compress and Warehouse Co., Galveston.

GALVESTON.

Galveston Council, No. 1, meets every 2nd and 4th Tuesday evenings at Engineers' Hall, S. W. Cor. Twenty-second and Strand Sts. Chief Engineer, Max Levy. Corresponding Engineer, A. L. Bradford, Union Depot.



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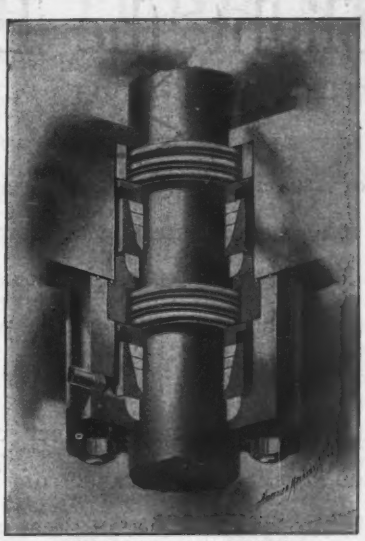

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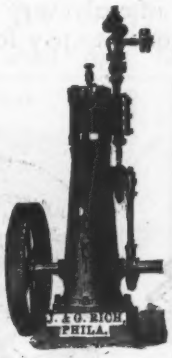

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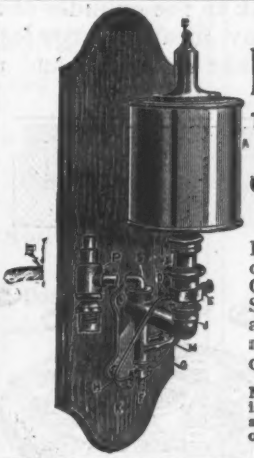

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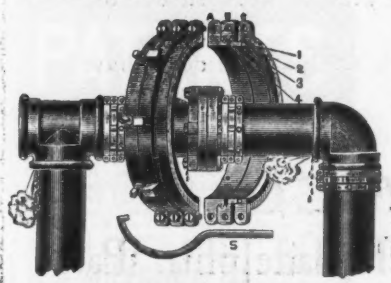

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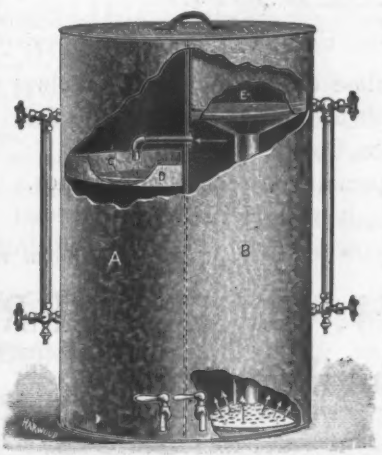

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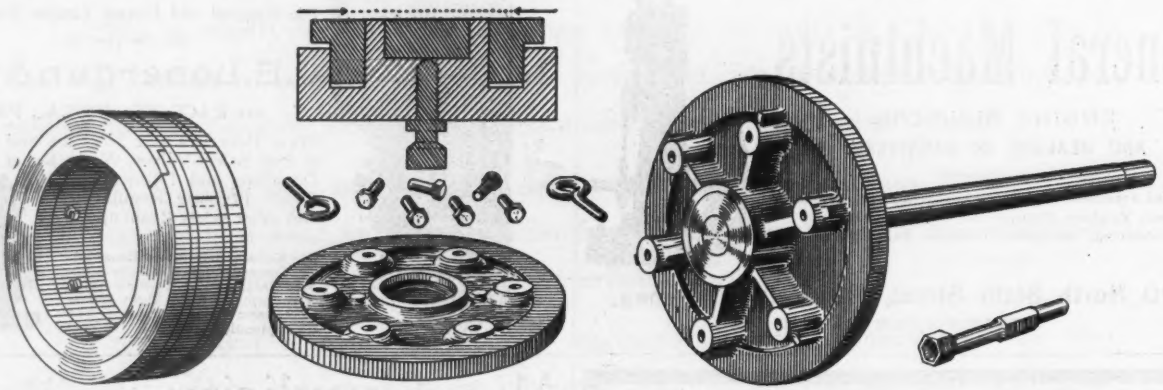

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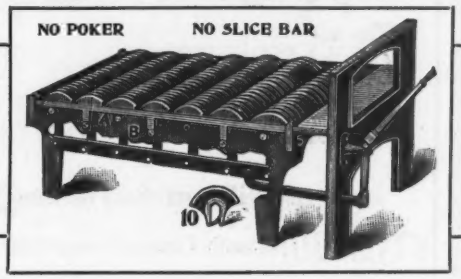

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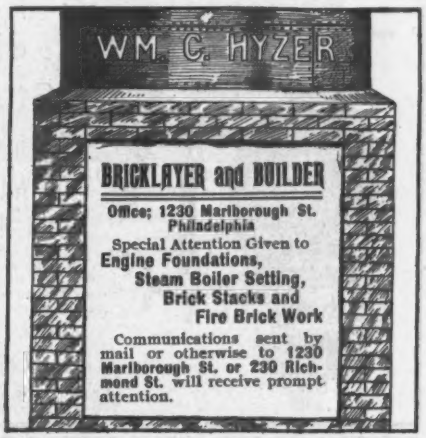
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That's easily remedied by cutting down the coal bills. Proof before pay.

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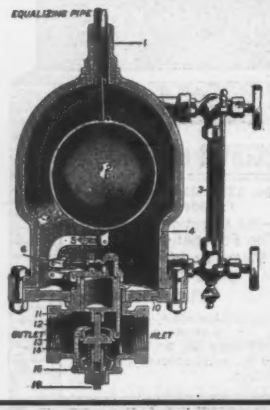

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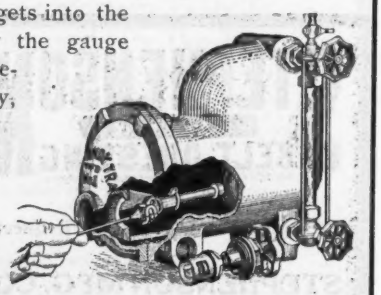

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Cleans the tubes without admitting steam into them. The soot goes up the chimney.

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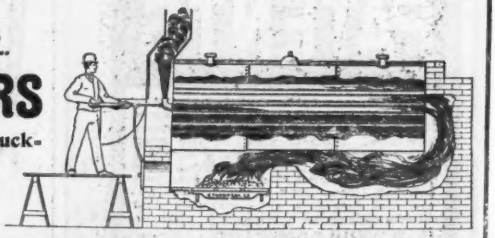

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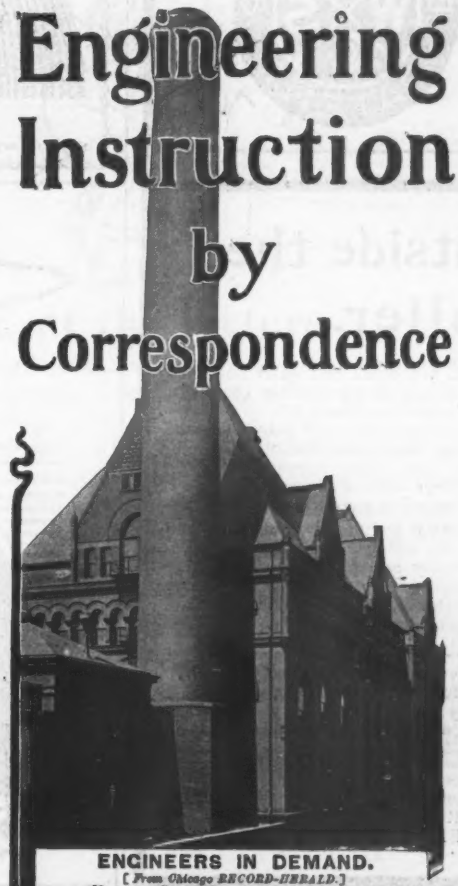

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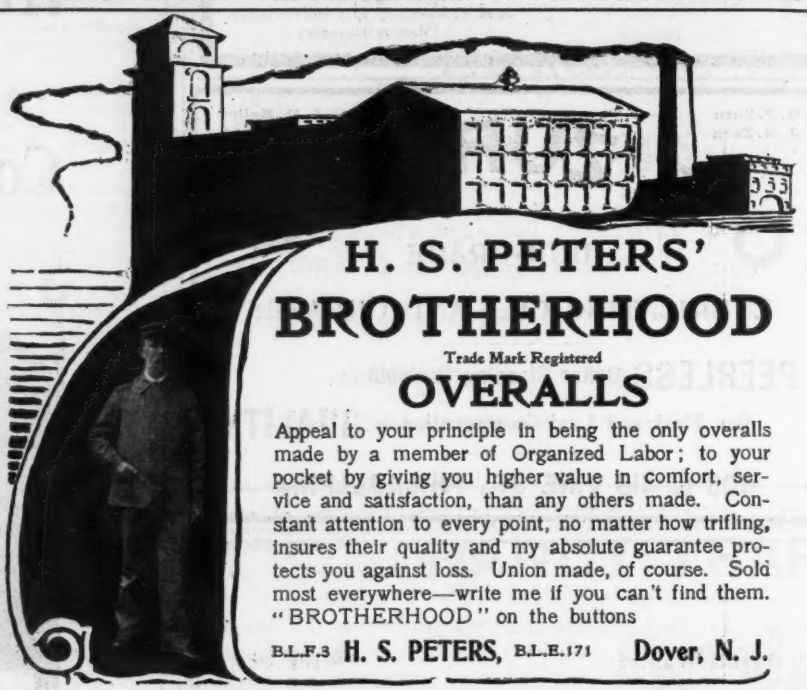

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Our compound is the result of years of experiments by an engineer of long experience, assisted by expert chemists.

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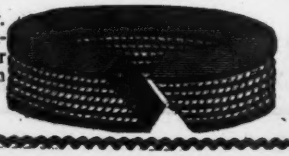
Self-lubricating, Steam and Water Tight, Less Friction than any other known packing. **None Genuine Without This Trade Mark Stamped on Wrapper.** All similar packings are imitations. In ordering give exact diameter of Stuffing Box and Piston Rod or Valve Stem. Our Packing is a sure cure for leaky stuffing boxes, whether the motion is rotary or reciprocating.



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made either with **Rubber or Canvas Core** and both **Round** and **Square** in shape. Will give satisfaction on Engine, Pump, Compressor and Valve Rods. Easiest of all packings on your rods.

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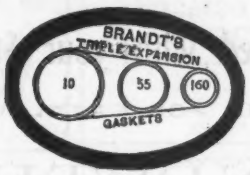

are the very best goods you can use in **High-Pressure** work. Engineers are requested to give the above a trial if they are not now using them.

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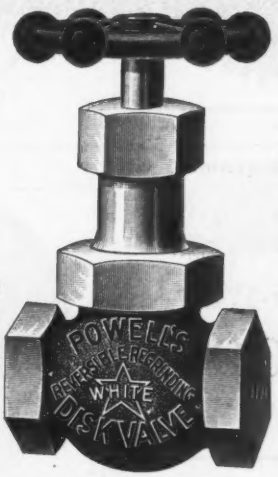
have a longer life and are easier to repair than any valve made.

They are sold with a guarantee of satisfaction or your money refunded. **Try one.**



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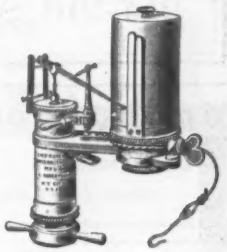
is as necessary to an engineer as a good watch to a railway conductor. This is **it,** Robertson Thompson and we are making a special price to engineers this month. Write to-day for particulars.



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paying fancy prices for things with pretty names. The **Hine Eliminator** takes a maximum of moisture out of your steam, and the price is very moderate. There's none better for extracting oil from exhaust.

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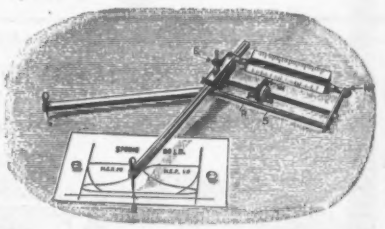

Write for our catalogue at once and get our special prices for this month. They will please you.

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FOR INTERIOR OF BOILER

This Separator will keep the water in your boiler. It will reduce the moisture ¾ of 1 per cent. It will stop priming, and furnish dry steam to the engine.

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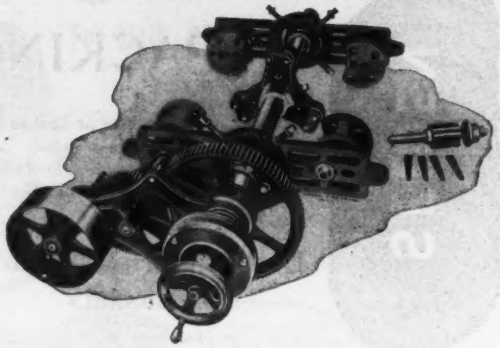
All types and sizes of Steam Engine Cylinders, Corliss Valve Pockets, Air Compressors and Pumps Rebored in present position, from 4 inches to 76 inches in diameter.



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All Troubles connected with your Steam Plant Rectified

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Put in as a waste product is taken out, refined, purified, ready for use.

This may hold good with other filters besides ours, but

We Claim

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will redeem MORE oil in LESS time than any filter of the same capacity. Just like placing so much money in your hand. Let us send you an Acme on 30 days' trial, at our expense.

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standing still, dead machinery, pays nothing in the coin of results. You reach that point by sticking to poor paints. Dynamos, engines and machinery give highest measure of service when you use

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For Steam, Air, Water, Oxide, Ammonia, Oil, etc.

ALL PRESSURES AND CONDITIONS.

FIFTY KINDS DEVOTED TO SPECIAL PURPOSES.

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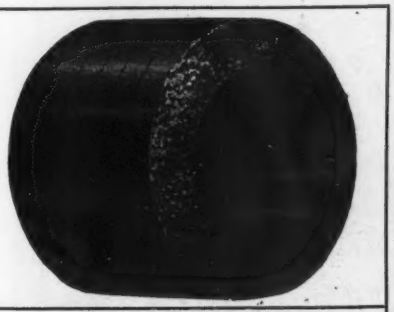

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You don't have to get any special box for our packing, it will fit any ordinary stuffing box, and it is just as pliable as any soft packing.

Make a note of our address, and give it a trial, you'll not regret it, for it is something you need.

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FOR EITHER HIGH OR LOW PRESSURE

Holds steam, water, air or ammonia with less friction on the rod than any other. Write for trial order to-day.

Watt's Best Sheet Packing

It is best because it makes any kind of a joint tight and keeps it tight. Used for oil, acid, steam, ammonia and water. It is the lightest and purest Rubber Packing made and can be used over again, and will not become hard under the highest steam pressure.

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LOW PRICE AND GOOD QUALITY. LET US CALL AND GIVE QUOTATION ON YOUR WORK.

Smith's Clamp for stopping leaks in pipe joints. Cheapest, simplest and most effective Clamp ever manufactured. Costs less than $1.00 per inch in diam. and much less in steel.

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Steam Specialties and Castings of Every Description. 45 N. Second St., Philadelphia.

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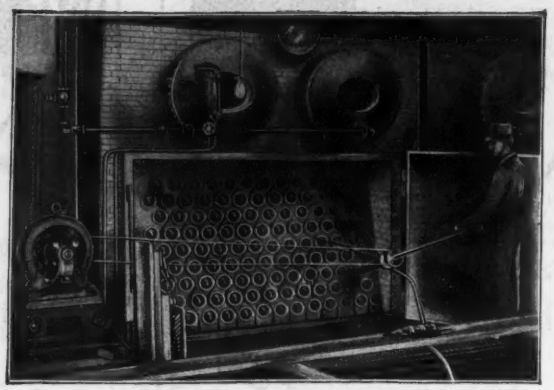
At work in B. & W. Boilers, at National Tube Works, McKeesport, Pa.

It is Simple, Easily attached, Quickly Changed, Cheaply Operated, Wonderfully Rapid and Durable.
Will remove any Kind or Condition of Scale. **We Guarantee It.**



Try OUR TURBINE—that's another style, but men who know say: "It beats them all." Mr. Weinland, its patentee, is the pioneer who "blazed the way" in this line. Others have merely imitated without equaling the true merit of our cleaner. **Sent on Trial Under Broad Guarantee.**

TRY OUR FEED WATER REGULATOR

The Lagonda Mfg. Co., Springfield, Ohio

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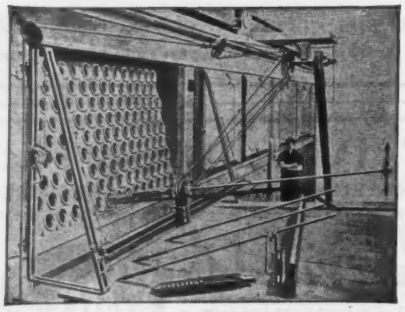

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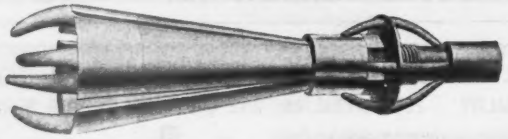
POWER OR IMPULSE

Are the oldest and most efficient Boiler Tube Cleaners on the market. They take out all the scale.



The Gem Flue Scraper

does the same for Smoke Flue Boilers

We also make **Gem Oilers,** Patent or Plain, **Torches and Heavy Brazed Steel Oilers, Flexible Shafting, Loose Pulley Lubricator.**

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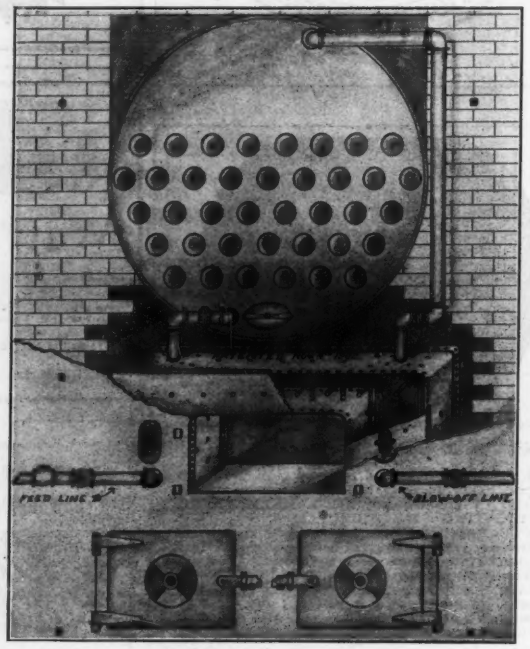

Saves the need of renewing brick arch; lasts as long as the boiler; increases capacity; does the work of a feed-water heater, and saves its cost in coal in a few weeks. You can't afford to be without it.

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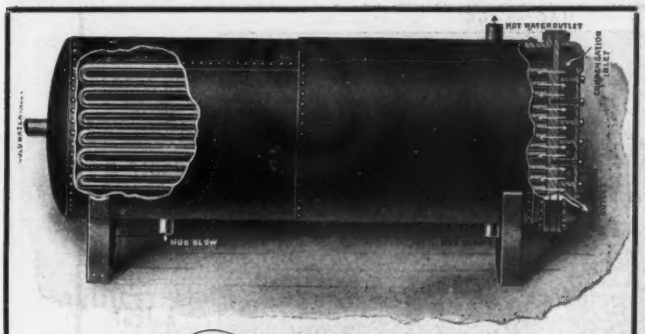
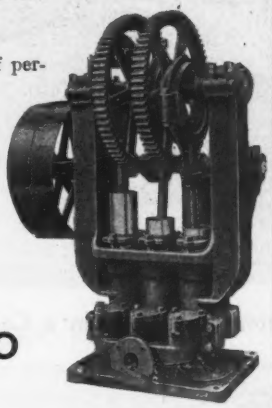


THE CLEANER
TRADE MARK

The **Cleaner** represents the acme of perfection in feed water heating.



The Davis Triplex Power Pump

is a perfect type of the vertical triplex belt driven pump.

Manufacturers of
The "Berryman" Feed Water Heater and Purifier

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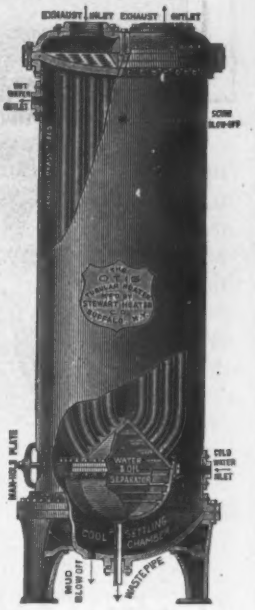
The OTIS Tubular Feed Water Heater, Oil Separator and Purifier

with Seamless Brass Tubes



Guaranteed

To heat the feed water to the boiling point (210 or 212 degrees) with the exhaust steam without causing any back pressure, **also to extract the oil from the exhaust,** so that the exhaust steam after being passed through the heater can be used for heating purposes, and the water of condensation for the heating system be returned to the boiler without the additional expense of an eliminator.

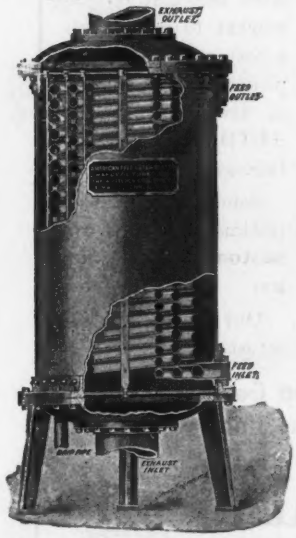
A Liberal Offer

If this heater fails to give satisfaction in every respect, we pay freight, cartage, etc., both ways.

The Stewart Heater Co.

11 Norfolk Ave., Buffalo, N. Y., U. S. A.

The American Standard Copper Coil Feed Water Heater



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Strength!
Economy!
A Money Saver!

It gives so little trouble that one of our customers, who has used one for 8 years, had forgotten that he had it when we asked him the other day how it was doing. He called in the engineer, who said it hadn't been touched since it was put in and was still heating the water to 210 degrees.

That's the kind of a Heater you want.

Write for Catalogue No. 100 P.

The Whitlock Coil Pipe Co.

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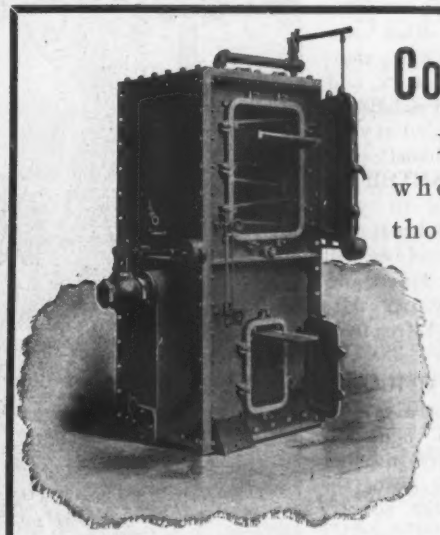

Convinced.

Many experts who honestly thought "thoroughfare" heaters the best, have been converted by the success of

THE WEBSTER FEED-WATER HEATERS AND PURIFIERS

The "no thoroughfare" principle not only economizes steam but gives far better results in many other ways.
Hadn't you better find out what has converted them?
Write for booklet.

Warren Webster & Co.

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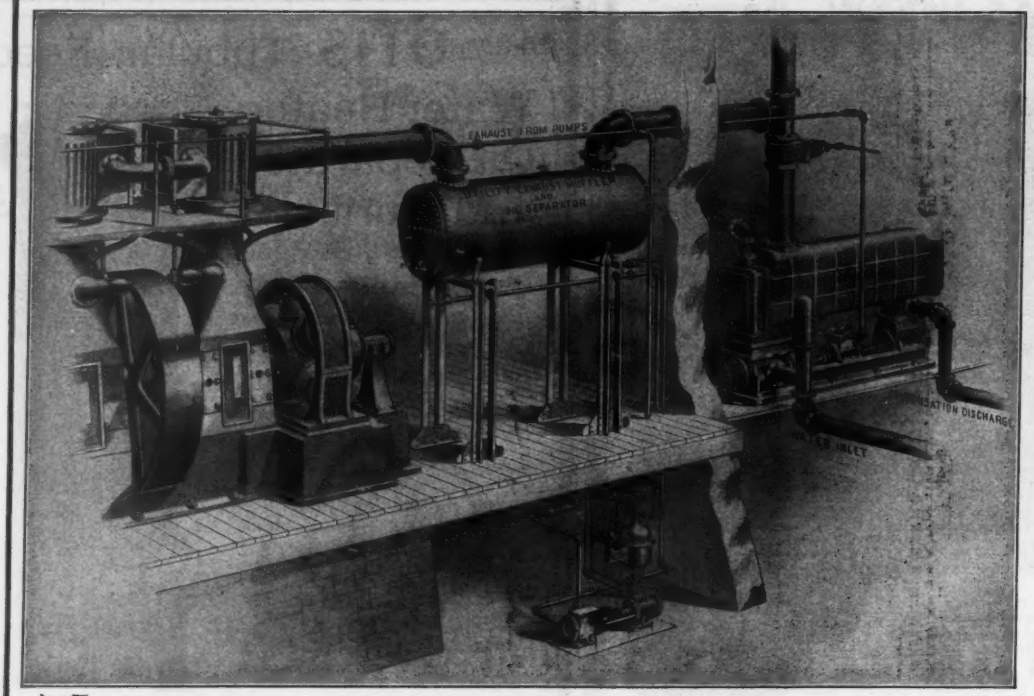


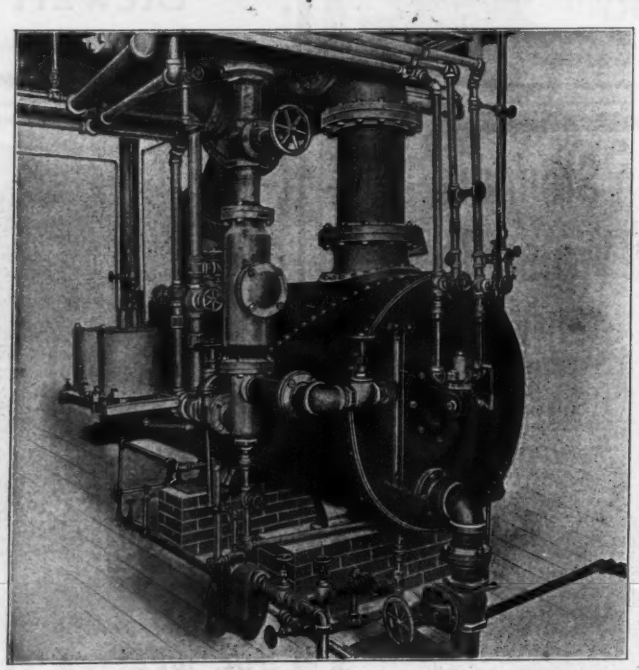
HOW IS THIS FOR A TEST OF OIL SEPARATION UNDER A VACUUM? SIZE No. 5 "UTILITY."

A TEST MADE BY F. R. HUTTON M. E., **Feeding Double** THE USUAL QUANTITY OF OIL, SHOWED AN EXTRACTION OF $99.\frac{9992}{10000}$%

Exhaust Muffler and Oil Separator as Installed in a Condensing Engine Plant.

We **GUARANTEE** the **"UTILITY"** the **BEST OIL SEPARATOR** on the market, either for condensing or non-condensing work, and it is **SELF-CLEANING**. Installed in your **MAIN** exhaust pipe we **GUARANTEE** you can return to your boilers all exhaust condensation and we will keep your boilers and heating system **ABSOLUTELY** free from **OIL**.

The **"UTILITY"** Feed Water Heater is simple in construction, requires no floor space, and heats the boiler water to 212 degrees.



Our **GUARANTEE** is based on the **CHEMICAL ANALYSIS** of the condensed exhaust steam **BEFORE** and **AFTER** passing through our device **WHICH IS POSITIVE PROOF.** We were the first on the market to show such a test and are always pleased to do it in any of the hundreds of **"UTILITY"** installations.

Send for booklet of testimonials. **Our customers talk for us.**

Our prices will interest you.

Exhaust Muffler, Oil Separator, Return Tank, Pump Governor and Feed Water Heater as Installed in a Non-Condensing Engine Plant.

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MANUFACTURERS OF

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ENGINES AND POWER INDICATED

We have a full line of Boring Bars for Boring Engine Cylinders, Crank Pin Holes, Cylinder Backs, and Corliss Engine Valve Ports, in present position.

Portable Milling Machine for Facing Valve Seats.

All Kinds of Engine and Pump Repairs done by Experienced Mechanics.

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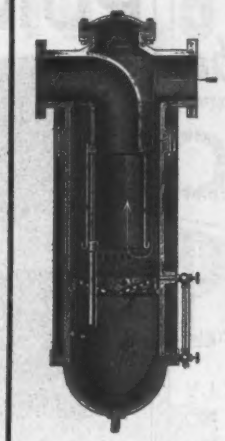

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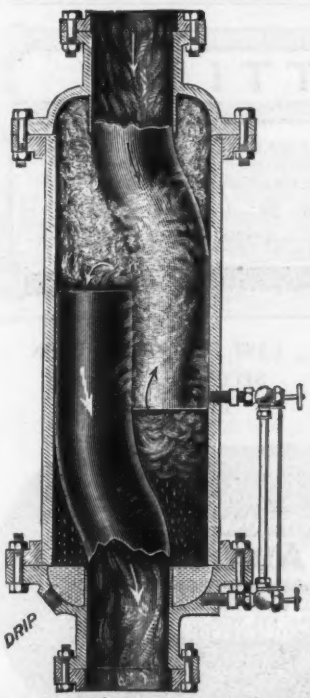
When you are told a separator takes oil and water from the steam current, *find out* where *it goes* and *what separates it*, that it will hold a lot of water, look up the weight and dimensions; that it's well finished, ask what covers it and where the work on it is, then send for our printed matter and put the stories together. We make all styles, for steam or oil, also **Exhaust Heads and Steam Traps.**

DIRECT SEPARATOR CO.

220 Marcellus St., SYRACUSE, NEW YORK

R. S. SPENCER, Philadelphia Representative, 1218 FILBERT ST.

The Stilwell Straight Way Steam Receiver Separator



furnishes dry steam, and with receiver capacity four times the area of in et, furnishes a larger volume of dry steam at its greatest efficiency at smallest working costs, to draw on than any other article for the purpose in the market, and makes possible the gain that comes from using dry steam.

Made in Vertical and Horizontal patterns.

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THE STILWELL MANUFACTURING AND STEAM SPECIALTY CO.

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THE BAUM SEPARATOR

For Live and Exhaust Steam

Horizontal Style for Live Steam or Oil Service

RESULTS GUARANTEED

For condensing systems use the BAUM VACUUM STYLE OIL EXTRACTOR.

Most Satisfactory Separator on the market. *Ask why.*

Vacuum Style Oil Extractor

The Baum Separator and Machine Company

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Feed Water Heaters and Purifiers

WATER-TUBE AND STEAM-TUBE

Cast Iron or Steel Shells. "∩" Shaped Seamless Drawn Brass Tubes

WE BUILD HEATERS FOR EVERY PURPOSE AND CONDITION

THE KELLEY PATENT

Improved Berryman Water Tube Feed Water Heater and Purifier

A thoroughly up-to date, reliable and efficient heater Made to stand the highest pressure; and so constructed as to be utterly indestructible by the heaviest boiler it is possible to carry. Write for catalogue.

We have a few good heaters, second-hand, which we will sell cheap, ranging from 50 H. P. to 1000 H. P. Mostly taken in trade for our Improved Berryman water tube Feed Water Heater and Purifier. Every heater is Tested and Guaranteed.

BENJ. F. KELLEY & SON, Makers

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The Tornado Boiler Tube Cleaner

Requires LESS steam than any other cleaner.
Will positively clean BETTER than scraper or brush.
Will clean ANY length tube.
In operation is EQUALLY balanced, insuring NO back pressure against operator.
Is the LIGHTEST and EASIEST cleaner to handle.
Has NO working parts.
Its force is tremendous.

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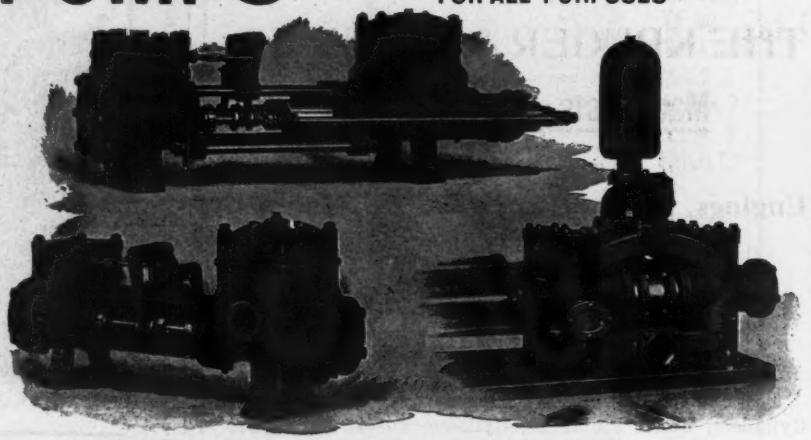

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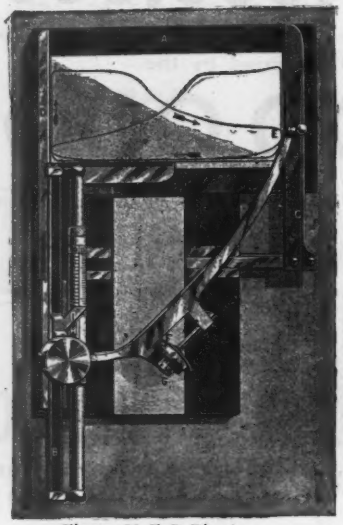

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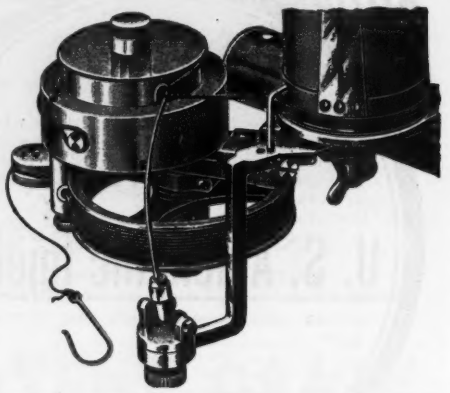

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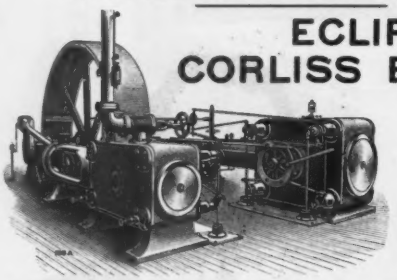

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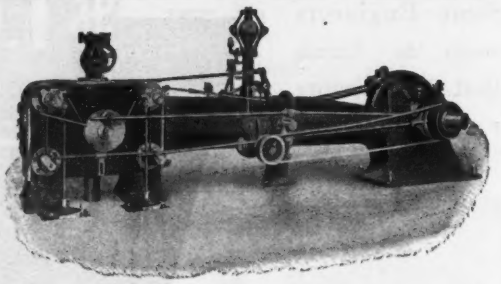

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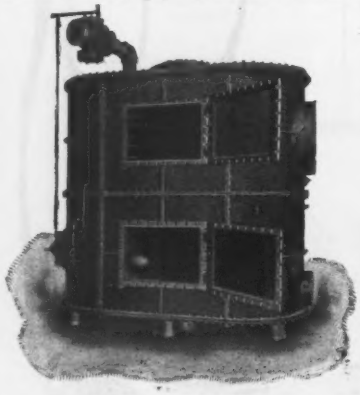

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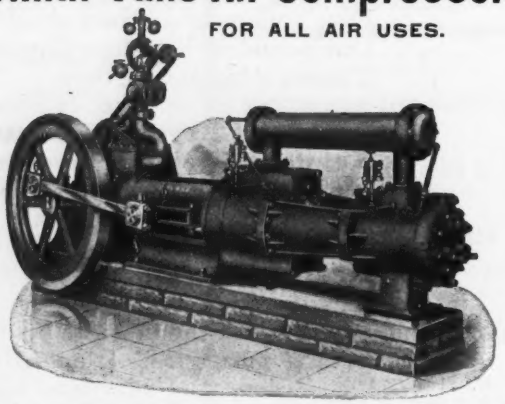

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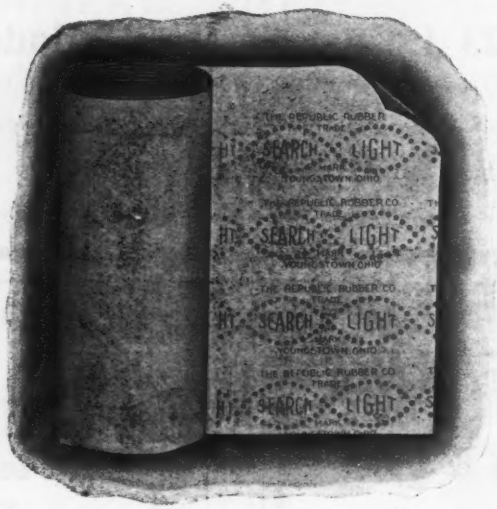

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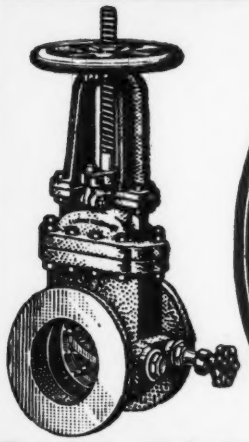

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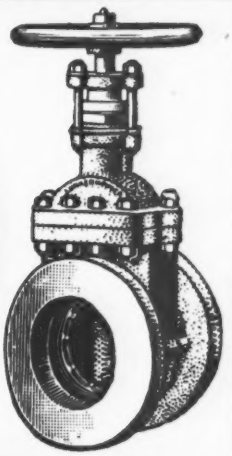

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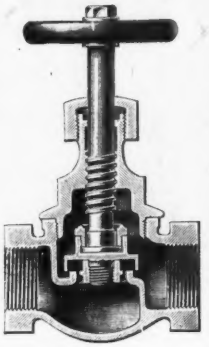

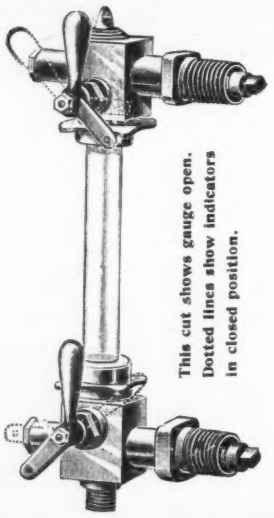

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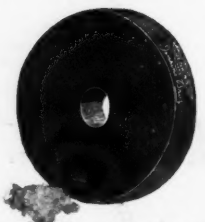

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